Teaching the disciplines in the MYP: Nurturing big ideas and deep understanding

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Middle Years Programme

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IB mission statement

The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.

To this end the organization works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.

These programmes encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right.

IB learner profile

The aim of all IB programmes is to develop internationally minded people who, recognizing their common humanity and shared guardianship of the planet, help to create a better and more peaceful world.

IB learners strive to be:

Inquirers They develop their natural curiosity. They acquire the skills necessary to conduct inquiry and research and show independence in learning. They actively enjoy learning and this love of learning will be sustained throughout their lives.

Knowledgeable They explore concepts, ideas and issues that have local and global significance. In so doing, they acquire in-depth knowledge and develop understanding across a broad and balanced range of disciplines.

Thinkers They exercise initiative in applying thinking skills critically and creatively to recognize and approach complex problems, and make reasoned, ethical decisions.

Communicators They understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in collaboration with others.

Principled They act with integrity and honesty, with a strong sense of fairness, justice and respect for the dignity of the individual, groups and communities. They take responsibility for their own actions and the consequences that accompany them.

Open-minded They understand and appreciate their own cultures and personal histories, and are open to the perspectives, values and traditions of other individuals and communities. They are accustomed to seeking and evaluating a range of points of view, and are willing to grow from the experience.

Caring They show empathy, compassion and respect towards the needs and feelings of others. They have a personal commitment to service, and act to make a positive difference to the lives of others and to the environment.

Risk-takers They approach unfamiliar situations and uncertainty with courage and forethought, and have the independence of spirit to explore new roles, ideas and strategies. They are brave and articulate in defending their beliefs.

Balanced They understand the importance of intellectual, physical and emotional balance to achieve personal well-being for themselves and others.

Reflective They give thoughtful consideration to their own learning and experience. They are able to assess and understand their strengths and limitations in order to support their learning and personal development.

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Preface

For teachers, a significant challenge can be determining what to prioritize in teaching and learning. In educational climates that place high priority on the coverage of content and accumulation of the knowledge necessary for students to advance to the next educational level, these decisions become even more challenging for educators trying to provide students with the tools they need to make sense of their natural, social and cultural worlds. The International Baccalaureate (IB) has always emphasized offering students a genuine purpose for learning and developing young people who are prepared to make the world a better place. High-quality, engaging and academically robust teaching that prepares students for the future demands that educators think deeply about what matters most for them to teach.

This publication, *Teaching the disciplines in the MYP: Nurturing big ideas and deep understanding* explores the meaning of disciplinary learning and considers what it means to truly understand languages, science and mathematics. It is designed to help teachers make decisions about what matters most to teach and learn, and argues that true disciplinary learning requires teachers to identify important conceptual understandings or big ideas that can help students use the discipline to make sense of the world in informed ways.

Meaningful **interdisciplinary learning** is the cornerstone of the Middle Years Programme (MYP) and is predicated on deep **disciplinary learning**. This publication explores disciplinary teaching and learning and outlines the rationale for a curriculum founded on these big ideas. It also examines the challenges such a curriculum can pose for students and offers guidance to teachers as they design MYP units in subject-specific-related concepts that can support students' interdisciplinary learning.

MYP teachers, particularly those working to implement the IB in settings where the curriculum is founded on a local, state or national curriculum will find practical guidance in this resource. Administrators responsible for curriculum development and alignment will also find this publication useful in aligning the MYP with other standards.

The introduction "On disciplinary understanding for all" explores the basis for and practice of a curriculum founded on deep disciplinary learning through big ideas. Following this introduction readers will find four discipline-specific chapters on language (one's own and others'), science and mathematics entitled "Teaching language A with deep understanding in mind"; "How can we best teach new languages? Considering core principles in language B instruction"; "Teaching for disciplinary understanding in science"; and "Teaching for disciplinary understanding in mathematics". Together, these chapters offer answers to questions about what to teach and how to maximize the limited time we have with students.

We hope this publication will help teachers prepare all students to understand ideas that are central to the Middle Years Programme and the Diploma Programme and apply them to become informed and thoughtful participants in today's societies.

On disciplinary understanding for all

By Veronica Boix Mansilla

Introduction

> When the bell rang, Ms Gomez's MYP science lab class ended as always. Noisy students rushed to put their materials away, while still comparing notes on their measurements of chemical reactions. Ayesha, a responsible student, approached Ms Gomez to inquire about whether today's activity would be on the test. "It is the thinking behind the activity that will, Ayesha. I will want to watch you think like a scientist to make sense of the chemical world around us," Ms Gomez replied. "But you did not give us the thinking behind the activity to study—like a study guide with what we need to know!" protested Ayesha. Ms Gomez recognized the challenge: Ayesha understood her responsibility to be one of studying a series of given propositions about chemical changes, molecules and mass. Ms Gomez viewed hers as one of teaching Ayesha how to apply principles of the atomic theory of matter to make sense of a variety of phenomena in the natural world.

The above example of an exchange between a student and a teacher illustrates the profound gap between two conceptions of knowledge, learning and schooling present in today's schools. Framed in stark contrast, the first outlook—the one Ayesha has come to learn throughout her years of schooling—views the disciplines as collections of information to be retained as a matter of cultural literacy. From this standpoint, learning is primarily about **having information**, and schooling is about helping students meet the information-accumulation requirements to move to the next grade or educational level. The second outlook views disciplines as dynamic conceptual tools (such as the atomic theory of matter), constructed by experts with the purpose of helping us **make sense of the natural, social and cultural worlds around us**. From this standpoint, learning is a matter of becoming able to **use disciplinary lenses with flexible expertise** in various situations. Schooling, in turn, aims to furnish students' minds with powerful lenses available in a society at a given time in order to help the young become keen interpreters of, and contributors to, the world in which they live (Gardner, Boix Mansilla 1994). Resulting from this higher expectation regarding knowledge, learning and schooling is students' readiness for **relevant learning** and **academically rigorous** curriculums like the IB Diploma Programme (DP).

Transforming our classrooms, from places where information is transmitted to places where students find opportunities to learn disciplinary ideas to make sense of the world, demands that teachers and curriculum developers reconsider what it matters most to teach. What does it mean to understand mathematics, science, or language (others' and one's own) in depth? Are there concepts and habits of mind that are so central to these disciplines that they enable students to make sense of a variety of the more specific topics, phenomena and problems we expect them to understand? How can our teaching approaches help us maximize the limited time we have with students? This publication examines these questions in the disciplines of mathematics, science, and languages A and B. We seek to support teachers in the task of helping **all** students aged 13 to 16 understand ideas that are central to these Middle Years Programme (MYP) subjects and apply them to become informed and thoughtful participants in today's societies.

Preparing to teach for disciplinary understanding is especially relevant for teachers working in the context of increasing cultural, linguistic or economic diversity. Powerful classroom learning experiences hold very

special value for students who typically only encounter models of academic values, critical analysis or effective argumentation at school. Our responsibility to engage these students in deep disciplinary learning cannot be overstated. All too often, however, teachers experience a tension between making their units engaging for less academically advantaged students and ensuring their disciplinary rigour. In this chapter and in the chapters to come, we propose that quality instruction can, and must, be both engaging and academically robust if we are to prepare students for the future. What we choose to teach, and how, is of the essence.

In order to support teachers in their efforts to nurture students' understanding, this chapter begins with a definition of disciplinary understanding essential to teaching a discipline well. Next, it examines how students learn the disciplines and the learning challenges that disciplinary understanding presents. We then address how units can be carefully designed to nurture deep and enduring understanding. The conclusion is dedicated to how teachers can support their own efforts for continuous growth in their disciplines and their teaching.

What is disciplinary understanding and why does it matter for students today?

Since time immemorial, human beings have sought to make sense of their natural environments, to understand the people and social groups with whom they interact, and to perfect the symbols they use when expressing their experiences and communicating with others. Over the centuries, cultures have developed increasingly systematic ways of thinking about these issues. Academic disciplines as we know them today—from contemporary physics and abstract algebra, to chemistry and literature—emerged in the 19th century when specialized university departments emerged, building on centuries of inquiry. Over time, communities of dedicated researchers have proposed, refined, rejected and revised theories, concepts, methods and disciplinary languages to advance a deep understanding of the world (Bruner 1960; Gardner 2000).

Disciplines are not certified collections of facts captured in textbooks. They are relatively new human inventions, unfolding dynamically at all times. Among experts today, new sub-disciplines emerge, such as biochemistry or history of science, creating new standards for what counts as reliable understanding of nature and the past. While the disciplinary findings that experts produce are always subject to revision, they constitute our societies' most reliable insights and forms of inquiry today and are, therefore, worth teaching in schools. They provide the foundations on which we build and carry out important societal tasks, such as curing disease, building bridges and understanding human experience or cultures.

Statements such as "the meaning we attribute to a given word depends on the context in which the word is uttered", "adding a number to both expressions of an equality does not change the equivalence between expressions", "offspring resemble their parents" and "introducing new species in an ecosystem may cause other species to become extinct" are not simple facts for students to remember. Rather, such statements result from a process of inquiry that deems them trustworthy according to standards shared by contemporary expert communities. In language, our understanding of the multiple meanings of terms stems from extensive analysis of communicative situations conducted by sociolinguists. In mathematics, acceptable statements follow standards of formal logic and mathematical proof. In biology, our understanding of ecosystems builds on extensive naturalistic observation, empirical experimentation and modelling that enable scientists to observe or manipulate variables to explain and predict how species innovations may affect the dynamic interdependence of species in a given environment.

To promote a deep understanding of statements such as the ones above, teachers face two challenges. First, they must identify key underlying concepts or **big ideas** that can help students make sense of the information presented in these statements, as well as other related information, cases or topics to be taught. A curriculum focused on big ideas strives to provide students not with definitions to remember but with

conceptual tools for sense making. So, rather than simply inviting students to define and identify native and foreign species in a given ecosystem, a big ideas curriculum may focus on the theory of evolution and its associated concepts of adaptation and natural selection and apply these to the ecosystem in question, as well as to other ecosystems and scenarios, both observed and hypothetical.

The second challenge teachers face when promoting a disciplinary understanding of the statements above entails helping students see that such statements are constructed human pursuits. Disciplines such as biology are clearly not lists of items to be covered during second period, three times a week (as Ayesha in our example above might have come to believe). Instead, they are best described as dynamic networks of big ideas, concepts, theories and examples, which experts produce through the use of ingenious methods and techniques in an attempt to answer relevant questions about particular aspects of the world. Students demonstrate deep disciplinary understanding when they exhibit flexible expertise in the use of significant disciplinary **knowledge**; when they have a good sense of the **methods** and procedures by which the discipline advances its work; when they have a good sense of the **purposes** driving inquiry in the discipline and the multiple applications that a given insight may have. Prepared students are also able to communicate using the academic language that is specific to the discipline in question. By inviting students to use the lenses of the biologist, the mathematician, the linguist or the poet to make sense of the world around them, we open students' minds to the most important cognitive achievements of our era.

In search of big ideas in disciplinary teaching and learning

A big ideas curriculum for a strong knowledge base

Clearly, students need to understand the fundamental concepts, theories and examples in the disciplines that they study. We rightfully expect that, after studying chemical reactions, students like Ayesha can describe qualities of certain gases, such as colour or solubility in chlorine, ammonia or oxygen, as well as conditions that affect them, such as pressure and temperature. Likewise, after learning about ecosystems, we expect our 13-year-old students to be able to define concepts such as species, reproduction or interdependence, name a variety of species in a given ecosystem, describe how food chains work, and tell what happens when a foreign species invades such an ecosystem. Students demonstrate disciplinary understanding when they can use concepts, theories and findings in the disciplines flexibly.

As experienced teachers know, however, not all ideas are equally essential. Often, the yearly curriculum appears as a long list of concepts to be taught. Teachers ask: What matters most for my students to understand? In curriculums crowded with content, and classrooms where time is limited and learning effortful, the question is especially relevant. What disciplinary ideas will have a greater impact on students' capacity to make sense of new information or phenomena in the discipline or in the world? In other words, how should we concentrate our time and effort strategically to maximize students' enduring disciplinary understanding? The answer is **a curriculum of big ideas and essential understandings.**

A curriculum of big ideas prioritizes disciplinary theories or concepts that hold the greatest power to explain a broad range of phenomena typically studied as independent curriculum topics. Ideas such as the theory of evolution (with its associated notions of natural selection and adaptation) in biology; the atomic theory of matter in physics; expressions (a way to represent, explore and reason quantitatively about situations) in mathematics; and the notion of polysemy (multiple meanings of terms) in language, stand as powerful examples of big ideas (National Research Council (NRC) 2000). In language, such big ideas may be best characterized as **core principles** that embody how language works.

Students demonstrate their understanding of big ideas and related significant concepts when they can reason accurately and flexibly with such concepts to "figure out" or "make sense of" phenomena that are

slightly novel. For example, Ayesha may use the atomic theory of matter to explain why gases react to changing temperature in a given way, how water is formed from (or separated into) oxygen and hydrogen, how mass and energy are conserved. Ayesha may also draw on her understanding of atomic theory to make sense of related phenomena outside of school, such as why diesel engines are more efficient than gasoline ones (Stone Wiske 1998; Perkins 2009).

Big ideas and disciplinary methods

Not all big ideas refer to the theories and findings produced by the disciplines. Big ideas may reflect methodological principles as well. For example, strong science instruction tends to focus on the nature of scientific inquiry with an emphasis on **evidence** and **causal explanations**. Clearly, evidence takes multiple forms and is subjected to multiple standards of acceptability (for example, naturalistic observations are accepted with criteria that are, in part, different from those used to accept experimental results). How we explain the causes of natural phenomena also varies greatly depending on the kind of problem scientists study. A big ideas curriculum in science focuses on an understanding of complex causality to help students understand how events or variables relate to one another to cause a phenomenon—sometimes in feedback loops, sometimes through discernible mechanisms, sometimes driven by a leading agent. Whether considering a unit on chemical structures, transformations or reactions, a close analysis of the evidence we have (or do not have) for given claims, and the explanations we deem acceptable, prepares students to consider matters of empirical evidence and explanation in other phenomena within the discipline or in life (Boix Mansilla 2010).

In mathematics too, a big ideas curriculum may focus on concepts such as **modelling** (representing and analysing functions), **solving equations** (by applying algorithms or using symbolic, graphic or numerical methods) or even advancing a mathematical proof. A focus on big ideas of this kind helps students understand that their work in linear functions, quadratic functions or exponential growth entails variations on one idea: the capacity to model or represent and analyse functions. Similarly, approaches to solving equations will present variations on the theme, depending on whether the equations are linear or quadratic.

In literature, the **close reading of text** appears as a standard approach to analyse and examine the construction of meaning. Students can apply this form of detailed reading and attentiveness to language detail in a broad range of texts—poetry, prose, drama, fiction, persuasive writing, blogs or comics. Here, too, close reading of text, with its emphasis on subject, form, message, imagery and rhythm, enables students to detect differences in effective language use across genres and to experience their learning of languages in more integrated ways, increasing their capacity to look deeply into texts by virtue of revisiting this big methodological idea multiple times throughout a course.

In summary, understanding **how** knowledge is built in a given discipline prepares students to build deep understanding of a broad series of topics within the discipline and related phenomena in life. In so doing, students have an opportunity to develop a disposition to be critical consumers of knowledge, able to exhibit healthy skepticism against oversimplified, biased and unsupported claims about nature, about human communication, or about patterns in the world. In the MYP, where students prepare for an academically demanding curriculum in the DP years, such a disposition becomes essential.

If big ideas related to disciplinary knowledge are about the **what** of a discipline, and ideas related to methods address the **how** of disciplinary inquiry, what can we say about the **why** of inquiring in a discipline?

Purpose—giving a meaningful direction to the big ideas curriculum

"Why do we have to learn this?" All too familiar, the question feels unsettling when raised plaintively by students, yet we must answer it genuinely. Responses such as "because it is important that you know this" or "because it is part of the course syllabus/test/state mandates" miss the point by failing to involve students in the quest for genuine disciplinary understanding. A broader reflection about the nature of disciplinary inquiry is in order. Why do individual mathematicians, scientists, poets, linguists or artists dedicate their lives to their quests? How do our societies use the findings of biology, mathematics or literature?

Whether in science, mathematics or literature, disciplinary knowledge emerges from our human need to understand and predict, to express a point of view, to create products and tools, to communicate more effectively or to solve complex problems. Disciplinary inquiry addresses questions that have inspired curiosity over the centuries such as: What is the world made of? Where do we come from? How can we communicate with others with clarity? Today, answers can be found in the atomic theory of matter, the theory of evolution or discourse theory in linguistics. Furthermore, disciplinary knowledge permeates the contexts in which students live, providing multiple opportunities for application. Physics concepts such as force and acceleration underlie the design of the cars and trains that take students to school. Supply and demand dynamics operate behind the products that line the shelves of supermarkets. Natural selection shapes the spread of a new strain of drug-resistant malaria, while artworks call society's attention to the importance of preserving our ecosystems.

A fundamental quality of deep disciplinary understanding is students' grasp of the purpose of disciplinary inquiry. Generally speaking, we can see the purpose of science as explaining and predicting natural phenomena; the purpose of mathematics as creating expressions that enable us to represent, examine and reason about patterns in formal logic and in the world. The purpose of literature can be framed as one of deepening our capacity to express points of view and understand the human condition through aesthetic language use. Students demonstrate disciplinary understanding when they can see the significance of a given idea, theory or problem—whether the idea connects to long-standing questions driving human curiosity or whether it can be applied to solve a problem, advance an explanation, create a product or produce a work of art. Ultimately, engaging students legitimately in the learning of a discipline (not merely through "hook" activities) requires that we help them understand why what they learn matters—intrinsically to them and to society.

The International Baccalaureate programmes are clear about the purpose of disciplinary learning. Rationales for the study of MYP and DP subjects do not emphasize formal graduation requirements. Instead, they stress genuine purposes for learning. For example, language A and language B are cast as tools for societal communication and personal reflection, fundamental to learning, thinking and the development of imagination and creativity through self-expression. Mathematics, in turn, is characterized as a powerful universal language, able to deepen analytical reasoning, as well as logical, abstract and critical thinking. Mathematics is cast as a language for problem-solving and decision-making in everyday life and in the workplace, and a foundation for the study of sciences, engineering, technology, economics and other social sciences. Science is geared to explaining, controlling and predicting the natural world.

Big ideas revisited

In summary, we have argued that disciplines such as mathematics, biology, chemistry and literature, far from being lists of topics to be transmitted, embody dynamic collections of vetted theories, core principles, findings and examples. These are constructed through the use of carefully developed methods to address long-standing questions, solve problems, create products or produce explanations of the world around us. Thus, quality teaching for disciplinary understanding engages students genuinely when we help them see the purpose of studying a certain concept or approach. Teaching a discipline for deep understanding invites teachers to reorganize what they are expected to teach around a small number of big ideas and associated concepts (from evolution to mathematical expressions). Through them, students develop the capacity to **think with** these ideas to explain phenomena, develop products, solve problems or raise new questions in informed ways.

A few qualities make a curriculum centred on big ideas especially promising. For example, big ideas:

- capture theories, core principles, findings or methods in a discipline, enabling students to develop core disciplinary habits of mind
- embody concepts that account for multiple topics typically taught as independent units, fostering a more integrated sense of the discipline

- enable sustained commitment to a few fundamental competencies that are revisited throughout the course under various topics, fostering deep and enduring understanding (less is more)
- embody concepts that can be used to account for phenomena outside of school—typically enhancing opportunities for transfer and relevance.

Crafting a big ideas curriculum invites teachers to re-examine the nature of their disciplines and the purposes for teaching them. It entails an important shift in outlook: from transmitting facts to helping all students construct disciplinary lenses to view the world. To embrace this outlook, teachers benefit from learning about the challenge that disciplinary understanding presents to the developing mind, a topic we turn to next.

Learning for disciplinary understanding

Preparing young students for the demands of a good high school and college education, complex work environments and challenging civic participation has become a pressing necessity in most countries around the world. Learning for disciplinary understanding has an important role to play in ensuring college and work readiness for all. While students can develop basic readiness skills, such as knowing how to study, manage their time or communicate clearly in a variety of ways, learning for **disciplinary understanding** enables students to grasp what it means to be an expert in a given domain. Students demonstrate their disciplinary understanding when they can apply disciplinary concepts, methods or findings flexibly and accurately to make sense of a given issue or phenomenon.

The challenge of building disciplinary understanding

Building disciplinary understanding is certainly challenging for students. Even the most experienced disciplinary teachers describe their dismay when, by the end of what they thought to be an outstanding unit, students' initial beliefs and misconceptions seem to remain untouched. The challenge stems from the fact that students' robust intuitive beliefs are frequently at odds with seemingly counter-intuitive disciplinary understanding (Gardner 2000; NRC 2000).

Early in life, people develop intuitive ideas about nature, about language, about how the human mind works, and about how narratives unfold. Many of these ideas, which have been extensively documented by developmental psychologists, are powerful precursors of sophisticated disciplinary understandings. For example, by the age of 5, children understand that narratives have beginnings, turning points and ends, and that the succession of events in them must "make sense" for the story to work. In literature, too, a novel must attend to matters of time: it should establish when and where a story begins, when and where it ends, and which turning points and actors' perspectives will be included.

Unfortunately, not all initial ideas are equally auspicious. Young children also tend to believe that stories are always about "good guys versus bad guys"—a belief that leads to oversimplifying a plot. Young students are inclined to attribute literal meaning to words, making symbolic interpretations of a term or a scene more difficult to come about. Most strikingly, students often project their own cultural values onto the minds and actions of characters in world literature, making ethnocentrism a difficult misconception to eradicate.

In science, too, students often hold the belief that experiments work if the result matches the one proposed by the textbook, that theories are simply unfounded beliefs (as opposed to well-founded conceptual systems), or that hypotheses are claims to be proven right (as opposed to tested). Even after years of schooling, students hold mistaken beliefs about how the solar system works, how electricity functions and how evolutionary changes come about (Corcoran, Mosher, Rogat 2009). In mathematics, students are often inclined to detach numbers from their meanings, filling in equations algorithmically—"number plugging". The task of addressing and transforming students' early misconceptions is daunting. Yet, when teachers can attend to how students learn best, and the kinds of learning challenges that their disciplines present, even the youngest children can develop more informed understandings (NRC 1996).

How do students learn for disciplinary understanding?

A landmark summary of the research on how students learn (NRC 2000) identified three fundamental principles that are important for teachers to consider in instructional design.

Students come to the classroom with prior knowledge that must be addressed if teaching is to be effective. If students' prior knowledge is not engaged, students may not grasp the newly learned ideas, or may learn them in ways that prove successful for a test but are rather short-lived. When they leave the test environment, it is their own constructed (even if naive) theories of the world that will prevail.

To engage all students in disciplinary understanding, teachers must find out students' prior knowledge and beliefs, and see how to engage them and transform them when necessary. This is especially important when working with students of varied cultural or linguistic backgrounds since such backgrounds will shape the meaning students make of the new ideas presented. Designing quality units of instruction begins by developing a strategy to learn about how students are thinking about the big ideas to be learned and how these ideas might connect to questions that drive their interests, or issues they view as important.

Students need to organize and use knowledge conceptually if we expect them to apply it beyond the classroom. To develop enduring disciplinary understanding, students must not only learn facts and information, they have to place these in a conceptual framework that will enable them to see how concepts make sense as a whole and apply to multiple situations. A big ideas curriculum of the kind described above invites teachers to identify conceptual frameworks, such as the atomic theory of matter, the theory of evolution, mathematic expressions or multiple meanings in language.

To link such conceptual frameworks with students' prior knowledge on the one hand, and human inquiry on the other, teachers may choose to present students with essential guiding questions. Doing so enhances students' sense of purpose and relevance in learning. Questions may include: What is the world made of and how do elements in the world change? How do species survive or perish in an environment? How can we express situations (for example, the relationship between poverty and education) to examine patterns and regularities? How can mathematical expressions help us make informed decisions (for example, predict the cost of a building at different scales)? How does context (special, cultural, situational) influence the way in which we interpret and use language?

Students learn more effectively if they understand how they learn and how to manage their own learning. Experienced teachers understand what research shows empirically: that a metacognitive approach to teaching can help students take better control of their learning and foster their critical-thinking capacities. Nurturing students' capacity to learn requires teachers to design instruction in which the learning goals are clear and genuinely embraced by students—a focus on big ideas, essential guiding questions and relevance matters here. It also requires teaching practices that examine how students reason about a given topic, apply the big idea, and change their minds over time as they enrich their understanding. When such ongoing monitoring is shared between students, teachers and peers, students have an opportunity to develop a language to think about, and make, decisions about their own learning. For students who view their capacity to learn and their intelligence as innate rather than as learnable, for students who view learning as a matter of acquiring information and not of "changing one's mind" about a given topic, a reflective and engaging approach to learning cannot be overemphasized.

Teaching for disciplinary understanding

Building on the learning principles above, teachers may ask: How can we best design instruction that nurtures deep disciplinary understanding? In particular, how can we do so given the constraints of time and curriculum coverage we typically face? What exactly should we do in our classrooms to ensure understanding? To address these questions, let us turn to five key questions that underlie quality instructional designs and examine how

productive responses to such questions are illustrated in a language A unit about argumentation. We do so using powerful questions that guide powerful learning-centred instructional designs (Perkins 2009).

Question 1: What is worth teaching and why?

Among the most challenging decisions teachers confront is that of selecting aspects in the curriculum that will merit deep examination for disciplinary learning. In the previous section, we examined the importance of "big disciplinary ideas" or "significant concepts" as a way to maximize teaching effectiveness. When deciding what is worth teaching and why, educators may weigh potential big ideas by asking: Is this a concept that underlies a variety of topics in my discipline? Is this a concept that my students will find helpful to understand in life as well as in their future studies and careers? Is this a concept that students may find challenging to learn without careful instruction? Can this concept be framed in ways that are engaging for students?

Judith Solebaum teaches 8th grade English in Boston, Massachusetts. She has chosen to focus her unit on "building arguments". She reasoned that argumentation is a form of academic discourse that her students do not typically learn outside of school; they will need it to succeed in high school, college and work. There are particular thinking and communicative moves that students will learn in this unit that will set the foundations for upcoming units on persuasive writing and debate. Judith identifies her big idea or core principle driving the appropriate use of language—she wants students to be able to "convey an academic stance". She thus frames her big idea in question form, which her students find more engaging: How can I employ language strategically to gain respect and persuade others about a complex scientific and social issue? Specifically, students will come to understand that academic discourse conveys a stance about the topics being discussed by:

- adjusting register to communicate context and purpose
- employing technical language and language of argumentation
- suggesting objectivity and healthy skepticism
- considering multiple sides to each argument.

Question 2: What is particularly challenging for students to learn?

Understanding the learning challenges a given topic presents enables teachers to concentrate their efforts strategically to build long-lasting understanding. Furthermore, having a developmental sense of how students might progress in their understanding gives teachers important tools to design instruction and assessment. For instance, drawing on prior years in teaching, Judith knows that her students often find distancing themselves from their arguments and points of view challenging. Students seldom employ forms that express arguments and counter-arguments (for example, "Although I generally agree with this position, I would argue that …"), express a personal stance (for example, "I strongly believe …", "I might disagree …") or transitions in an argumentative text (for example, "On the one hand … on the other hand …", "In conclusion …"). Furthermore, Judith recognizes that while nuance and complexity are valued features in academic argumentation, students often have difficulty articulating a position other than their own. They struggle to acknowledge the limitations of their own position or the strengths in a contrary one. She understands that, in addition to teaching students about the discursive forms of academic argumentation, she would also need to instruct them on how to convey an academic stance—one that demonstrates parsimony and rationality, authority, personal detachment and consideration of multiple points of view. She also knows that, to be effective, she will need to assess students early on to find out their strengths and misconceptions.

Question 3: Which learning experiences will best yield, and demonstrate, students' deepening understanding?

Designing learning experiences or assignments that firmly invite students to apply concepts and knowledge in novel ways is central to teaching for deep disciplinary understanding. In many good classrooms, students are actively engaged in learning. They may be working in groups, crafting a response or developing a

product. However, not all engaging activities yield the kind of deep understanding described above. Teachers interested in maximizing the effectiveness of their instruction with the goal of deep understanding will craft assignments or activities in such a way that it would be impossible for students to complete the assigned task successfully unless they understood the particular key concept, idea or skill being taught. While many activities and assignments can be engaging, only those that invite students to "apply" or "think with" the concepts being taught in novel situations will yield deep understanding. Assignments of this kind can be described as **performances of understanding** in that they advance and demonstrate a given understanding at the same time.

Judith's unit on academic argumentation includes a variety of performances of understanding of this kind. Three, taking place at different points in the unit, are described below.

1. **Analysing discursive forms in a genetically modified food (GMF) debate.** Judith opens the unit with a problem: population explosion is likely to compromise our ability to feed the planet. GMF—one of the solutions scientists propose—could help us address the challenge but, at the same time, presents problems for our ecosystems and survival. Judith invites students to examine a filmed debate among scientists about the advantages and disadvantages of genetically engineered food as a solution for world hunger. The students' task is to write a brief personal response commenting on the arguments they found most convincing and the expressions participants used that suggested intellectual authority. This initial performance enables Judith to gauge students' readiness for critical analysis of argumentation—one that considers not only the complexity and nuance of an argument but also how linguistic expressions are used to convey a stance and self-presentation.

2. **Changing the register of a GMF speech to convey an academic stance.** By mid unit, students have been exposed to communicative patterns typical of academic discourse—markers of objectivity, a disinterested stance, and healthy skepticism evident in the use of the impersonal subject, conditional language and consideration of counter-arguments. A supportive science teacher has also provided the class with key readings on the topic of GMF, addressing not only its production and assessed risks, but also matters of public opinion. Students are asked to:

   - use the readings to create a table of arguments for and against GMF, including comments and the limitations of the arguments they identify
   - edit a political speech on GMF.

   In this assignment, students take on the role of speech writers for a local politician. Their task is to transform an emotional town hall speech the politician gave in support of GMF into a suitable speech to open a scientific gathering. To succeed in this task, students must use language to convey an academic stance.

3. **Participating proficiently in an academic debate on GMF.** The final performance of understanding for this unit involves a fishbowl oral debate on the topic of GMF. Taking turns, students engage in a public debate with the assistance of a student moderator. Debating teams and observers (guided by observation criteria on argumentative language, academic stance and form of argument) rotate to allow all students to participate. Each debate is followed by the observers' analysis. Each group's debate is recorded and then analysed by the group in search of improvements relating to the three criteria described.

Question 4: How can we tell whether students are making progress?

As indicated in the previous section, performances of understanding not only invite students to construct but also to exhibit their understanding of a given problem at a given moment in time. Assessing student understanding involves examining performances with a constructively critical eye. Quality assessment is tied to the goals of a unit or course: it is carried out by teachers, peers and students themselves; it is conducted formally through performance-based tests, and informally by looking closely at student work. Most

importantly, assessment takes place against the background of given criteria depicting a continuum of levels of performance. In Judith's unit, such student development is assessed along the following criteria:

- from single-perspective arguments to arguments that include counter-arguments and rebuttals
- from using everyday life discourse and grammar to employing academic terms and forms appropriately
- from using expressions that convey a spontaneous and engaged stance towards GMF to using language effectively to convey a detached and authoritative stance.

In Judith's unit, students and teacher employ these criteria to gauge their progress and inform further steps. As the criteria are well aligned with the unit goals and big idea, they elegantly support deep understanding.

Question 5: What have we learned?

The final question asked by teachers interested in nurturing deep disciplinary understanding is a rather reflective one. As a unit unfolds, or soon after it is completed, teachers interested in perfecting their practice ask: What have we learned from this unit that can inform better instruction ahead? Asked early in a unit, the question enables teachers to adjust their designs mid course. Asked towards the end of a unit, the question enables teachers to adjust future units. As units are focused on big ideas in each discipline, the opportunities for revisiting such big ideas are numerous throughout the academic year.

In reflecting on her unit, Judith remarked that her students needed more scaffolding than she had given, in order to consider the dynamic relationship between arguments, counter-arguments and rebuttals. Creating concept maps based on the readings students had on GMF had not been enough to ensure that all students viewed the move of first recognizing the strengths of a contrary argument before rebutting it as a means of strengthening their case. She also noticed that, not accustomed to academic forms of argumentation that conveys an authoritative and detached style, students needed additional support to perform more comfortably when communicating orally in an academic genre. Such a form of discourse clearly violated traditional communication norms among the students' peers. She considered addressing this point explicitly in the units to come, and hypothesized whether framing the task as "role playing" might help.

In summary

Teaching for disciplinary understanding requires that teachers consider the five core questions given above in the order they deem most productive. Essential to quality unit designs are selectiveness and depth of their understanding goals: a few big disciplinary ideas or significant concepts to be examined in depth is better than a broad list of learning goals only partially touched upon. Key to engaging and productive unit designs is careful crafting of learning experiences. These experiences should engage students in working directly with the big ideas and key concepts in a unit, giving them multiple opportunities to apply them in slightly novel and increasingly independent situations. Assessment is ongoing and informative, as are teachers' reflections about their own unit design.

To conclude: Teachers who learn

Teachers like Ms Gomez and Judith Solebaum in this chapter embody models of professionalism in teaching. These individuals understand their disciplines deeply and flexibly enough to distinguish ideas that matter most for students to learn, and devise multiple approaches to support student understanding. They are able to diagnose students' understanding at different points in a unit and envision the next developmental steps. They know how to design learning experiences that demand that students build and demonstrate nuanced understanding. They are not distracted by efforts to make curriculums engaging at the expense of disciplinary depth. Rather, they aspire to generate curriculums that students will find engaging and relevant **and** that will yield enduring understanding at the same time.

Perhaps the most important marker of these teachers' professionalism is their ongoing disposition to reflect on and improve their practice. Professionalism in teaching does not mean transmitting large and static bodies of information to students. Rather, it means bringing an inquiring stance to the practice of nurturing students' capacity to make sense of the world in which they live. Dispositions such as curiosity about student learning, the sharing of expertise, the courage to try out new ideas, to analyse student work with colleagues and to document key learning designs for further reflection are at a premium in professional teaching today. Such professionalism is nurtured best when teachers have a chance to construct and participate in vibrant teaching and learning communities. Professional communities support teachers in their efforts to perfect their practice, to sharpen their analyses, to remain up to date. At a time when global expectations for student readiness for life, further studies and work have reached a new height, great teachers are not necessarily those who have more information. Great teachers today are teachers who learn.

References

Boix Mansilla, V. 2010. *MYP Guide to interdisciplinary teaching and learning*. Cardiff, UK. International Baccalaureate.

Boix Mansilla, V and Gardner, H. 1998. "What are the qualities of understanding?" In M Stone Wiske, (ed). *Teaching for Understanding: Linking Research with Practice*. San Francisco, California, USA. Jossey-Bass.

Bruner, JS. 1960. *The Process of Education*. Cambridge, Massachusetts, USA. Harvard University Press.

Corcoran, T, Mosher, F and Rogat, A. 2009. *Learning Progressions in Science: An Evidence-Based Approach to Reform*. Number RR-63. Philadelphia, Pennsylvania, USA. Consortium for Policy Research in Education, University of Pennsylvania.

Darling Hammond, L. 2008. *Powerful Learning: What We Know about Teaching for Understanding*. San Francisco, California, USA. Jossey-Bass.

Gardner H. 2000. *The Disciplined Mind: Beyond Facts and Standardized Tests, the K–12 Education That Every Child Deserves*. New York, USA. Penguin Books.

Gardner, H and Boix Mansilla, V. 1994. "Teaching for understanding in the disciplines and beyond". *Teachers College Record*. Vol 96, number 2. Pp 198–218.

National Research Council (NRC). 1996. *National Science Education Standards*. Washington, DC, USA. National Academy Press.

National Research Council (NRC). 2000. *How People Learn: Brain, Mind, Experience and School*. Washington, DC, USA. National Academy Press, Committee on Developments in the Science of Learning.

National Research Council (NRC). 2005. Washington, DC, USA. National Academy Press, Committee on How People Learn.

Perkins, D. 1998. "What is understanding?" In M Stone Wiske, (ed). *Teaching for Understanding: Linking Research with Practice*. San Francisco, California, USA. Jossey-Bass.

Perkins, D. 2009. *Making Learning Whole. How Seven Principles of Teaching Can Transform Education*. San Francisco, California, USA. Jossey-Bass.

Stone Wiske, M, (ed). 1998. *Teaching for Understanding: Linking Research with Practice*. San Francisco, California, USA. Jossey-Bass.

Teaching language A with deep understanding in mind

By Paola Uccelli with Veronica Boix Mansilla

Why should we help students understand language?

The ability to use language lies at the core of who we are as humans. Language offers a means of self-expression, of entering and understanding others' worlds and minds, of exploring meaningful questions that defy scientific answers, and of transcending the here and now so that we can reflect about the past and the future. In addition, highly relevant learning processes, such as reasoning with others, expressing one's knowledge and thoughts, and accessing knowledge and perspectives that lie beyond our personal experiences, are performed overwhelmingly through language in our society, inside and outside of school. Since ancient times, educators have known and used the power of language and literature to enable self-reflection, rhetorical abilities, intellectual growth, and exploration of essential questions about life, self and humanity. Whereas this pedagogical practice continues an ancient tradition, promoting in-depth understanding and mastery of linguistic expression, comprehension and interpretation is especially crucial nowadays. First, in an increasingly globalized world, where distinct cultures, identities and interests coexist in the same physical or virtual spaces, students need to learn how to interact successfully with different audiences and to process linguistic information from a variety of sources. Second, our current world is not only increasingly interconnected via language (for example, internet-based communication, texting), but has moved from an industrial economy into a new knowledge-based economy with accelerating language and literacy demands. Today, being able to access constantly changing information and new knowledge constitutes a central requirement for active participation in society and for professional success. Consequently, language and literacy skills have become more prevalent than ever and education needs to respond accordingly. Finally, in a fast-paced society that is progressively focused on pragmatic concerns of economic progress and individual success, schools are among the few places where students can engage in in-depth reflection of core human dilemmas through close reading and critical language reflection.

How can teachers respond to students' changing language and literacy needs in a globalized world with a new knowledge-based economy driven by a fast-paced pragmatically focused society? Are the views of language instruction with which we grew up sufficient to prepare our students for the new communicative demands of today's world? If not, how might we reconsider what matters most for students to learn about today in their language classes and across the curriculum?

In this chapter we propose that quality language and literacy instruction must focus on helping students build a fluent understanding of a few fundamental qualities of language. Specifically, we claim that in order to thrive as effective communicators and critical consumers in today's societies, students will benefit from understanding a core set of principles guiding appropriate language use. Five ideas are proposed:

1. **Language as context-driven.** Language varies according to context, audience and purpose of communication.
2. **Language as multiple meanings.** Language forms, such as words or expressions, have multiple meanings that are actively co-constructed.
3. **Language as position.** Language not only conveys information but also a personal stance.
4. **Language as argument.** Later academic language is essentially argumentative.
5. **Language as exploration.** Language is a means for self-expression, exploration of self and others' worlds and minds and profound meaning-making.

These five ideas conform to a core of implicit concepts about the nature of language underlying recent research on language and literacy development, and are aligned with the language conceptualization that informed the recent Common Core State Standards (USA). As such, they are worth making visible for teachers and students and revisiting over time through multiple units of instruction—from a lesson on classical literature to one on persuasive writing.

In what follows, we begin by defining **core principles** or big ideas about how language works illustrating them with examples. We then turn our attention to how students develop competence in these areas. We ask: What learning challenges do students encounter and how do they move from less to more competent language use? A section on curriculum and instruction follows, where we identify qualities of powerful assignments and illustrate them with excerpts of a unit designed for the Middle Years Programme (MYP). We conclude with a series of practical recommendations for teachers charged with preparing students to master language and literacy skills.

As you will notice, this chapter does not focus on the frequently discussed aspects of literature that are ubiquitous and central in language arts instruction. Instead, it focuses on the nature of language, which is ironically a much less discussed topic in the context of English language arts pedagogy.

What is language? Core principles in language A

We all have a strong intuitive sense of what language is. After all, we use language regularly in multiple contexts in our daily lives. However, using language all the time does not necessarily turn us into reflective or successful language users across all possible contexts. Preparing students for more demanding communicative contexts requires that we ask questions of ourselves: What are the most important aspects of language that students need to understand in depth to become effective language users? If there were just a few core qualities of language that teachers needed to take into account to unlock students' capacity to perform in a variety of contexts, what would these key ideas be?

Throughout the history of the discipline, different linguists have defined language in different ways, drawing attention to particular aspects of our language system. Some theories have taken a narrow focus to view language as an abstract system of words and grammar while others have come to view language more comprehensively as socially situated discourse. In other words, while some linguists focus on the characteristics of language at the sentence level (that is, words and abstract grammatical rules), others attempt to understand language at the level of connected sentences, asking questions such as: How do speakers construct narratives or persuasive arguments? What forms do speakers need to learn to produce a definition or a description for a particular purpose? Despite the multitude of perspectives and the charged debates among linguists, there are some uncontroversial assertions about the nature of language with which few linguists would disagree (Hudson 2008) and which can serve as a powerful foundation for a language curriculum. We have used these assertions to construct the five core principles or big ideas proposed in this chapter. For example, most experts agree that language varies according to context, audience and communicative intent. Experts also agree that, when using language, individuals communicate more than mere information. Moreover, it is uncontroversial to assert that the way in which we use language signals who we are, who we think our audience is and how we choose to present ourselves.

The MYP language A course seeks to encourage and enable students to use language "as a vehicle for thought, creativity, reflection, learning, self-expression and social interaction". Students are expected to develop the skills involved in "listening, speaking, reading, writing, viewing and presenting" in a variety of contexts. They are challenged to develop "critical, creative and personal approaches to studying and analysing literary and non-literary works", engaging in literature from a variety of cultures and historical periods including their own. Language is manifest in a variety of texts and genres, including digital communication (International Baccalaureate 2009). To guide their students,

teachers must pose a fundamental question: What are the most important concepts my students need to understand about the nature of language in order to meet these aims in age-appropriate and sophisticated ways?

To address teachers' legitimate concerns, let us revisit the five core concepts on the nature of language introduced previously—the fact that language varies according to context, audience and purpose of communication; that words or expressions, have multiple and actively co-constructed meanings; that language does not only convey information but also a personal stance; that academic language is essentially argumentative; and that language is a means for self-expression, exploration of self and others' worlds and minds, and profound meaning-making.

Students who understand these concepts are tooled to perform better in a variety of communicative situations—from self-expression to reading comprehension to literary interpretation—and across a broad spectrum of text types—from digital to poems to scientific prose. In this sense, the five core concepts may work as foundational disciplinary areas to consider for the design of an IB language A curriculum and units of instruction—areas that are aligned with current recommendations from pedagogical research in language and adolescent literacy.

Language as context-driven

Language forms vary according to the audience, context and purpose of communication. A single "individual will speak or write differently in different social contexts" (Hudson 2008). This simple but revealing idea has substantial implications for pedagogy. Research has offered robust evidence that language continues to develop during adolescence. Becoming an expert language user entails learning an increasing repertoire of forms that one can use and understand flexibly in a larger set of situations, orally and in writing. Schools, as particular social contexts, require specific forms of language. Thus, from the vast array of language forms used in the world, at school students are socialized into a selective set, that is, the forms and functions of academic discourse. Three important dimensions of contrast need to be considered in academic language instruction. These are outlined below.

Registers: everyday language versus academic language

Academic language, also called the language of school, the language of science or advanced literacy, is different from everyday language. Moreover, control over the language of school is a requirement for success in challenging literacy tasks, such as reading textbooks or writing school-valued genres across content areas. Yet many students who are highly successful in communicating in informal contexts via everyday language may struggle with the demands posed by the language of school (Halliday 2004). The following examples illustrate how academic language differs from the more colloquial forms of everyday speech.

Box 1

a. Everyday language[1]

I am worried because one day the politicians might explode a nuclear bomb and everyone will die.

b. Academic language

Concern has been expressed over the possible detonation of a nuclear device that could result in widespread mortality.

[1]First example taken from Derewianka (1991).

Box 2

a. Everyday language

Water changes into steam when it gets warmer. We are worried because water is changing into steam faster than before. This is happening because the weather is getting warmer.

b. Academic language

The increasing evaporation of water caused by rising temperatures is alarming.

As we can observe in the above examples, academic language is filled with abstract nouns, passive voice, nominalizations and complex syntactic structures. Clearly, it would be unexpected for someone to express a concern to a friend using the academic language of Box 1 b. In the same way, students are not expected to use everyday language in school assignments but are expected to produce and understand language forms that are closer to Box 2 b (as opposed to Box 1 a. or Box 2 a) in their later years of school. As Halliday (2004) claims, these forms of academic language have evolved in the scientific community as ways to pack more ideas in fewer words and to talk more efficiently about phenomena as static objects that can be further studied. As these examples demonstrate, at school students continue to learn more abstract vocabulary, complex structures and particular ways of packing information that differ from their everyday communication. Students will become skillful producers and interpreters of such forms through sufficient guided exposure, extensive opportunities to practise and contrastive analysis of language across contexts.

Language varieties: Vernacular varieties versus Standard English

A note about language varieties is necessary here. Whereas students need to master academic language, they need to do this while simultaneously valuing their home language practices. Dialects or language varieties, such as African–American Vernacular or Chicano English, are rule-governed systems with comparable complexity and as regularly patterned as more prestigious language varieties, such as Standard English (Crystal 1997; Farr, Ball 1999; Solano-Flores 2006). Students who speak language varieties different from Standard English need to learn how to code-switch from everyday language (where their home language is appropriate with friends, possibly on radio stations and other contexts) to Standard English in particular contexts. The key idea here is that students and teachers need to understand that language varieties are not incorrect or correct forms of language, but are alternative language patterns appropriate for specific purposes, audiences and contexts.

Genres: Narration versus exposition versus persuasion

Finally, different genres or text types (for example, narratives, expository texts) make use of somewhat different constellations of language skills. For instance, narratives require speakers/writers to use temporal markers, and persons or other animate beings as subjects. In contrast, expository texts require mostly atemporal, generalized propositions in timeless present, abstract nouns, and markers of causal and logical connections among ideas. Consequently, students who are experts in understanding and producing narrative texts are not necessarily equipped to understand or produce other types of texts. In fact, abundant practice with narrative text will not prepare students for understanding or producing other types of texts, such as persuasive essays or expository texts. Thus, instead of planning only general opportunities for students to produce language, teachers are encouraged to design activities that provide students with abundant practice in analysing and producing the specific types of texts that they expect their students to master at school. For instance, if students are expected to master persuasive essay writing, they will need to be exposed repeatedly to this type of text and they need to write multiple persuasive essays throughout the school year. In addition, they will greatly benefit from contrastive analysis, that is, analysing a persuasive essay versus a narrative about the same topic, or identifying particular features of persuasive essays on the same topic but written for different audiences. It is through repeated practice, reflective exposure and critical analysis that students develop nuanced understandings of particular types of texts.

How do students' skills in using language as context-driven develop over time?

Major developmental trends can be detected with regard to how students become fluent in their understanding of how language is shaped by the audience, context and purpose of communication. Young children are able to shift their language to address different audiences from early on in life. Research shows, for instance, that 5-year-olds distinguish the language used to greet a baby from the language addressed to an unfamiliar adult. Nonetheless, when students enter school they need to learn an increasing repertoire of language forms flexibly for different contexts and audiences. Students need to move from highly contextual and concrete uses of language (for example, "Pass me the salt" or "I want this [pointing to an object]") to rely more on language as its own context (that is, without using pointing or gestures or intonation as supports for meaning-making) to convey ideas. In this context, two main developmental advances during the school years need to be highlighted. First, students gradually learn more abstract language forms required to discuss increasingly complex school topics. Second, students need to understand what forms to select for particular purposes in contexts marked by intangible and less clear audiences. While the challenges of early language development involve assessing the knowledge needs of a present interlocutor during face-to-face conversation, the later challenges of the language of school require students to enter "conversations" via reading or writing with interlocutors that are often unclear and with language expectations that they might not fully understand. Thus, development does not only involve learning more words and structures, it also requires that students understand what forms are appropriate for what functions and in what contexts (What forms do I choose to emphasize an idea in a formal persuasive essay? What forms are most appropriate in writing a precise text analysis? How are these forms different from the ones I would use to explain this to a friend?).

While the transition from the language of home to the language of school requires substantial learning for all children, this transition tends to be more challenging for students who do not engage in school-like language at home. Progressively, during the middle school years, this learning continues and students need to learn to navigate a yet larger repertoire of forms, adding to the well-mastered informal face-to-face conversational and narrative skills the new qualities of abstraction, precision and conciseness characteristic of the later language of school. Over time, they expand their abilities to understand and produce not only narrative texts but a larger variety of text types serving multiple functions (that is, description, exposition, persuasion). Young children learn the different forms to address a baby versus an adult because they have had the opportunity to participate repeatedly in both situations, hearing and producing the language required in each context. Analogously, older students will learn the forms and match the forms with the appropriate contexts through multiple exposures and productions of the particular text types valued at school.

Summary of students' developing ability to calibrate language to a variety of contexts—including academic ones

- from physically supported to linguistically autonomous communication
- from informal to formal style
- from concrete to abstract topics
- from narrative to expository texts

Language as multiple meanings

Language forms have multiple meanings that are actively co-constructed. In constructing meaning from and through text, students need to become aware that language forms have different connotations and shades of meaning. Students also need to understand that meanings are negotiated and co-constructed. Through close reading and vocabulary instruction, students learn to operate with words that have multiple meanings (for example, "bank" as an institution to save money or as the bank of a river) and with literary texts that have literal as well as more figurative interpretations. This simple yet powerful idea is not always obvious to students. Research shows that readers can be trapped in the most basic meaning of a word without having developed the semantic flexibility or the sufficient word knowledge that allows them to identify the appropriate meaning or the subtle connotation of a word in a particular context. Alternatively, readers might engage in free subjective interpretation without using textual evidence as the basis for their claims. Moreover, many students assert that it was only during high school that they "discovered" that literary texts could allow multiple interpretations. Research suggests that making the polysemous (multiple meaning) and co-constructed nature of words and texts explicit and visible for students via explicit instruction and high-quality, text-based discussion is highly beneficial.

How does student competence in viewing language as having multiple meanings develop over time?

It is estimated that by high school graduation students need to master around 40,000 to 60,000 words. Research suggests that an average English-speaking student enters kindergarten with an approximate vocabulary of 3,000 to 5,000 words and learns approximately 3,000 to 5,000 words per year. Whereas the number of words to be learned is vast, being a successful language user entails not only knowing thousands of words but also knowing words in depth. Word knowledge is incremental and multidimensional. This means that words are not learned by studying a simple definition once and being tested on it, but by using the target word, by encountering it in multiple contexts and by gradually expanding the meaning from a basic superficial knowledge to connotations, multiple meanings, semantic associations and figurative uses of words. Developmental research also indicates that concrete, tangible words (such as "dog" or "forest") are easier to learn than abstract and conceptually complex words (such as "melancholy" or "theory"). Interestingly, research has demonstrated that vocabulary is an area of enormous individual variation, and one in which teachers can make a considerable contribution in scaffolding students' progress. To help students to not only expand their vocabulary repertoire but also understand that language forms can be interpreted in multiple ways and that meaning is constructed, explicit instruction on vocabulary, as well as close reading accompanied by high-quality text discussions are critical to foster the necessary flexibility involved in interpreting language.

Summary of students' developing competence in viewing language forms as having multiple meanings

- from basic to in-depth word knowledge
- from single meaning to multiple interpretations
- from literal to figurative interpretation

Language as position or personal stance

Language conveys information, as well as a personal stance. As students are required to gradually produce and comprehend more complex texts, they need to understand that information is always conveyed along with a writer's or speaker's stance. Speakers signal their personal stance—or personal attitude—from

early on in development. For example, a 4-year-old child might tell a personal anecdote in a loud voice and emphasize, "She was very, very, very bad". Over time, speakers need to gradually learn more sophisticated devices to convey a personal attitude (for example, "I would tend to disagree with …"). Furthermore, students need to understand which stance is expected in different situations: a more involved emphatic stance in everyday conversations (for example, "I tell you!" or "This is awful!") as opposed to the more cautious and detached stance that is characteristic of academic communication (for example, "These findings suggest that this theory might have some weaknesses …"). Being aware of this dimension, and learning an array of expressions to convey personal stance, facilitates both students' transition towards becoming more effective and thoughtful writers and speakers as well as more careful and critical readers and listeners.

How does student competence to understand language as embodying a personal stance develop over time?

Available research in this area suggests that while students can quite spontaneously become able to communicate in ways that express an involved stance, it is only through instruction and practice in a wider range of communicative situations that they learn to employ complex means to express and comprehend the more cautious and detached stance that is characteristic of professional and academic communication. For instance, elementary school students are known to be able to use auxiliary verbs in their daily communication (for example, "**May** I have an ice cream?"), but it is only during the later years of school that these students learn to use auxiliary verbs to communicate degrees of certainty in their writing (for example, "Some argue that global warming **may** not be a real threat"). The cautious and detached stance typical of academic discourse is a later development in students' language, and learning how to convey a personal stance without using the informal markers of an involved and absolute attitude is a key gradual accomplishment of the later school years. Making this dimension visible for students through repeated exposure, increased reflective production and contrastive analysis is highly beneficial for students to achieve nuanced and critical interpretations of perspective in text and to be able to construct their own position by consciously selecting from a wide repertoire of forms and functions.

Summary of students' developing competence in using language to convey a personal stance

- from using volume, intonation and enactment to using an expanding set of language forms flexibly to express personal stance
- from an involved to a detached academic stance
- from spontaneous speech to authoritative stance
- from an emphatic or absolute to a cautious epistemic stance

Language as argument

Later academic language is, at its core, argumentative. Academic writing essentially involves supporting or disconfirming a theory and constructing a position towards some piece of knowledge. During the middle school and high school years, students are required to analyse, critique, evaluate and synthesize information to produce their own learning and their own reasoned arguments. However, the new developmental challenges that adolescents encounter are not only for production. As students engage with argumentative text, they are expected to comprehend and to question a text's authority. Nonetheless, research has shown that the critical reading of argumentative discourse is challenging and that students need to be highly scaffolded to be able to engage in constructive criticism of argumentative text. As students grow older, a critical expectation is that they learn to compare and contrast, synthesize

and integrate different sources of information (which may include digital sources). Among several other aspects, such as learning to evaluate sources and developing perspective-taking and reasoning skills, attention to the language of argumentation in texts is critical to facilitate students' effective integration of information from multiple sources.

As discussed above, academic language can be a barrier for student success during the higher grades. Thus, young adolescents will benefit from opportunities to learn and understand new language forms characteristic of argumentative discourse. For instance, students will benefit from explicit attention to forms used to express arguments and counter-arguments (for example, "Although I partially agree with the author, I would argue that …"), to express personal stance (for example, "I strongly believe …", "I would be inclined to disagree …") and to mark transitions in text (for example, "One reason … another reason …"; "On the one hand … on the other hand…", "In conclusion …"). Explicit attention to language, in the context of meaningful activities and authentic communication, will not only help students become conscious of their language choices and better readers but will also start to prepare them for the multiple-document literacies required in later grades and in post-secondary education. Multiple-document literacy skills refer to the abilities required to construct a meaningful synthesis and complex understanding from multiple texts that address the same topic from different perspectives. This is the type of complex task that readers need to succeed at in the later years of high school, in college and when doing research for personal or professional purposes beyond school.

How do students develop their academic language competence?

Developmental research suggests that students shift from an inclination to employ persuasive forms based on opinion and effect to increasingly favouring forms of argumentation that are evidence-based. Students' competence also develops from considering a single perspective aligned with your own to evaluating and contrasting multiple perspectives and counter-arguments, and from building arguments based on a single source to multiple-document integration. This development, however, will be closely tied to the opportunities for production and exposure that students have encountered.

Important developmental accomplishments include understanding the difference between claims and evidence, understanding the organization of argumentative texts, and being able to identify and construct not only arguments but also more challenging components of argumentation: counter-arguments and rebuttals.

Summary of students' developing academic language competence

- from uncritical assimilation to critical reading
- from opinion to evidence-based claims
- from single to multiple perspectives
- from one-sided arguments to counter-arguments and rebuttals

Language as exploration

Language is a main means for self-expression, for understanding others' worlds and minds and for engaging in profound meaning-making questions. The IB has a tradition of pursuing this goal and achieving successful outcomes. If IB teachers integrate the four core concepts discussed above into their current lesson plans and pedagogical practices, this self-reflection and others' reflections will only become deeper. Prior research and expert practitioners recommend emotional involvement for true understanding and deep processing of literary texts. In addition, research from literature, reading and socio-emotional development highlights the learning progression idea of moving from personal, to local, to global. This entails beginning with students' personal concerns and prior background knowledge, then moving to think

about proximal others, and only subsequently considering distal others in increasingly larger spaces (Selman 2003). This approach provides students with unique opportunities to engage with deep philosophical questions or ethical issues through close reading of literature. When literature texts are discussed, as related to deep human questions or topics, students learn to connect their own concerns and experiences—such as those about love, suffering, frustration, resilience—to those faced by characters and, in this way, literature can become an incredibly powerful source of both personal growth and exploration of others' minds and worlds. High-quality, text-based discussions that move from the personal to local and global dimensions, and incorporate students' personal experiences and concerns, have the potential to turn students into lifelong readers of meaningful literature.

Designing instruction: Helping students to become expert users of language

The MYP and DP frameworks for curricular design, and the IB goal of situating language and literature learning in relevant contexts for students and of engaging students in big, meaningful questions, offer an efficient platform to incorporate **core ideas about language** into instructional designs. But how can teachers ensure that they are helping students develop core language and literacy concepts of the kinds described here? To answer this question, in what follows we first illustrate the distinction between very engaging and general unit designs in language A and unit designs that purposefully target particular language and literacy skills in meaningful contexts. Second, we outline the kinds of learning experiences that have proven most successful in nurturing the specific skills outlined above. Third, we share a series of more generic qualities of exemplary instruction in language A.

From engaging units and meaningful contexts to units that also focus on key language-specific core concepts

To illustrate how teachers may adjust their instructional design to focus most strategically on core language and literacy development goals, consider, for instance, a unit entitled "Constructing meaning". An initial version of this unit may characterize the driving **significant concept** as "Literature is a source of wisdom about self, society and human nature" and the **unit question** as "How, and to what extent, is literature a reflection of self, society and human nature?" In its initial design, the unit planner described the unit's summative assessment as follows. Students "will create a letter that influences change in society". In addition, activities listed throughout the unit included an oral debate and an analysis of "Obama's 'Yes We Can' speech" to learn presentation and persuasion skills.

Revisiting this design with the **language-specific core concepts** in mind proves productive. Given the unit's context and content, "**language as position**" and "**language as argumentation**" could be selected as the leading language-specific ideas or core concepts for this unit. To integrate this with the significant concept, the unit question can become: "How do authors use **language choices** to persuade others to reflect about themselves and society and to carry specific actions?" Whereas all domains would be considered in the design, if "**language as position**" **and** "**language as argumentation**" are the ones prioritized for their relevance to the content, then more specific objectives and assessments related to the construction of persuasive texts and, more specifically, to the use of markers of stance can be added. When crafting units of instruction teachers embark on the process of translating general aspirations or programme-level aims into learning goals that can be examined within a unit and that focus more directly on language competencies. Consider the general objectives listed in Box 3 below, and examine how they could be replaced with more specific, strategically selected and cohesive unit-level objectives listed in the second box.

Box 3

Content

Use language to narrate, describe, analyse, explain, argue, persuade, inform and express feelings.

Organization

Organize ideas and arguments in a sustained, coherent and logical manner.

Box 4

Content objectives linked to "language as position"

Use language **to construct a position by** arguing, persuading, informing and expressing feelings.

Organization objectives linked to "language as position"

Understand and practise the structure of arguments (thesis, arguments, counter-arguments, rebuttals, conclusion), both orally and in writing, and use a variety of markers to express personal stance.

With the significant idea of **language as position** and the specific objectives focused on argumentation, persuasion and stance, teachers can more strategically scaffold the key linguistic dimensions necessary to master this type of text and content for comprehension, production and nuanced interpretation. Students can be asked to analyse text and identify logical connectors (for example, "therefore", "consequently", "nonetheless") and markers of degree of certainty (for example, "evidently", "conclusively", "impossible", "most likely"), as well as markers of attitudinal content (for example, "unfortunately", "happily", "significant"), across a variety of persuasive texts that they analyse and produce oral speeches, written opinion articles, oral debates and so on. An additional complement would be to have teachers carefully provide guided instruction and sufficient repeated practice with the language forms and functions they expect students to master in each unit.

Nurturing student understanding of the five core language concepts

To promote students' linguistic and communicative expertise, teachers can employ and adapt strategies that have been investigated in recent research, which we synthesize here. For example, we have asserted that students need to understand that **language is shaped by the audience, context and purpose of communication**. Today, we know that in order to achieve this learning goal students need to participate in activities where they analyse and produce the same genre repeatedly over several weeks, and also contrast texts read or produced on the same topic but for different purposes (for example, an opinion article on the importance of ethnic diversity, an expository text summarizing current demographics in the United States, and a narrative centred around issues of ethnicity). Textual analysis, abundant reading and discussion, and plenty of opportunities to produce, reflect and improve specific genres (drafting, editing and reviewing) in the context of a dialogue about the communicative purpose and the audience of particular texts makes visible for students what language forms are expected, available and effective. (See "Appendix 3: Teaching to foster genre knowledge and audience awareness" for specific recommendations and relevant references on writing and genre knowledge.)

For students to understand that **language forms have multiple meanings that are actively co-constructed** and that **language not only conveys information but also conveys a personal stance**, the most current research points towards explicit instruction on vocabulary, strategies to unpack text, and writing strategies, as well as towards high-quality, text-based conversations as crucial components to advance students' language, textual analysis and writing skills. Research suggests that students benefit from explicit instruction in vocabulary, reading and general writing strategies to help them develop an awareness of multiple meanings

and a reflection on writers' perspectives. (See "Appendix 1: Explicit instruction in vocabulary, reading and writing" for specific details about recommendations and corresponding relevant references.) Moreover, discussions that are text-based and of high quality also help students to develop the knowledge that language has multiple meanings and serves to convey a personal stance. In a large study, Applebee, Langer, Nystrand and Gamoran (2003) found that on average, in a 60-minute class session, students engaged in discussion for less than 1.7 minutes. Importantly, adolescents in classrooms that evidenced a more discussion-oriented approach experienced more literacy growth than students in classes where discussion was less common. This growth may be a result of the additional time afforded to students to hear and participate in multiple interpretations of a text. This suggests that, to be effective, discussions must be allocated ample instructional time. Two particularly successful pedagogical models that scaffold high-quality discussion in the classroom are "Collaborative reasoning" and "Questioning the author". (See "Appendix 2: Supporting high-quality, text-based discussions that foster textual understanding" for specific recommendations and references.)

Students' understanding that **later academic language is essentially argumentative** involves understanding that writing and reading academic texts requires entering a conversation that has already started and that will continue. As students join a conversation for a brief moment via distanced communication through language, they need to learn to acknowledge their ideas, anticipate or review those of others, take a skeptical stance towards authoritative texts, and precisely and clearly entertain multiple perspectives to make their own ideas and/or knowledge visible and understandable. Again, explicit instruction on the components of argumentation, as well as oral practice in argumentation followed by writing argumentative essays have shown positive gains in students' argumentative skills. Learning a metalanguage to talk about argumentation ("claim", "evidence", "argument", "counter-argument", "rebuttal") helps students understand the components of an academic argument. Argumentative skills practised during oral debate in collaborative formats have been shown to transfer to students' argumentative writing. (See "Appendix 4: Teaching to foster argumentation skills" for specific recommendations and relevant references on argumentation skills.)

Finally, the notion of **language as a main means for self-expression, for entering and understanding others' worlds and minds, and for engaging in profound meaning-making questions** is already the driving force in IB curriculum planning. Certainly, students should not engage in language, reading and writing for the sake of learning new forms but as a way of exploring problems about self and others, for expanding their worlds and their understanding of others through essential questions relevant to all human beings. Students will benefit from encountering at school multicultural texts that offer "mirrors and windows" (Sleeter 2005); in other words, texts that reflect their own realities and identities, but also texts that open students' worlds to new adventures, ideas and ways of being. (See "Appendix 5: Literacy instruction that considers what motivates adolescents" for specific recommendations on self-expression, multiculturalism and motivation, as well as relevant references.) Recent research has shown some positive qualitative effects when teachers use students' language and culture preferences, such as hip hop, TV or internet films and shows, to develop critical skills and as bridges to less accessible and more unfamiliar literature. Morrell (2002, as cited in Moje 2007: 30) argues that adolescents who participated in an intervention that incorporated youth language and cultural preferences "honed critical research skills, understood the relationship between literature, popular culture, and their everyday lives, and … translated their experiences in quality oral debates and expository pieces". Thus, respectfully and authentically incorporating youth culture and language practices as valuable and rich forms of expressions and as bridges to classic literature seems to be a promising approach.

What conditions enable students to develop language and literacy skills more generally?

In order to support students' language abilities, teachers must create conditions that are rich in communicative opportunities. From developmental linguistics research, we know that students make substantial progress in language and literacy skills when provided with:

- high motivation to communicate a message (that is, "Why is a topic or an activity relevant?")

- a clear relationship between self and audience (that is, "Who am I as a speaker/writer and who is my audience? Who is the author and what is he or she trying to say?")
- frequent and active social participation in a particular genre (that is, for instance, many opportunities to debate so that students can become good at this particular genre)
- the support of a collaborative interlocutor that expands the student's language forms through shared discourse (that is, opportunities for discussion in which the teacher can model responses, paraphrase complex fragments of text, extend students' comments and ask questions)
- engaging read-aloud texts that expand their knowledge about self, about others, about the world and that provide new language resources (that is, high-quality, text-based discussions where the processes of comprehension, analysis and reasoning are made visible via the use of language).

Given such conditions, students are able to learn increasingly complex forms to communicate their messages to particular audiences and to acquire the constellation of features characteristic of the genres they have practised recurrently. Thus, developmental linguistics findings suggest that recreating these conditions in the classroom of later language learners should provide a language-rich environment conducive to students' favourable and enjoyable learning. We understand language assessment and instruction as reciprocal processes, where informal and formal assessments inform instruction, and vice versa, in a recurrent and mutually beneficial relationship. (See "Appendix 6: Assessing language use" for research-based recommendations on assessment practices.)

In summary, to maximize the effectiveness of unit designs—that is, their capacity to promote deep and enduring understandings in language A—teachers are invited to pay very close attention to the few most significant concepts in language defined above and to craft learning goals, assignments and assessment approaches that target these skills directly. As these five core concepts are foundational to language and literacy expertise, they constitute the building blocks of a broad range of possible unit themes, from Renaissance poetry to film to essay writing to contemporary fiction to online political campaigning. As students gain practice revisiting these few core concepts in a broad spiralled curriculum—which allows students to revisit ideas as they move forward in their learning—they are more likely to build enduring understanding of how language forms work and how we assign meaning to them, keeping purpose, context and audience in mind.

References

Applebee, AN, Langer, JA, Nystrand, M and Gamoran, A. 2003. "Discussion-based approaches to developing understanding: Classroom instruction and student performance in middle and high school English". *American Educational Research Journal*. Vol 40, number 3. Pp 685–730.

Crystal, D. 1997. *The Cambridge Encyclopaedia of Language, Second Edition*. Cambridge, UK. Cambridge University Press.

Derewianka, B. 1991. *Exploring How Texts Work*. Newtown, Australia. Primary English Teaching Association.

Farr, M and Ball, AF. 1999. "Standard English". In B Spolsky, (ed). *Concise encyclopaedia of educational linguistics*. Oxford, UK. Elsevier.

Halliday, MAK. 2004. "On the language of physical science". In J Webster, (ed). *The Language of Physical Science*. London, UK. Continuum.

Hudson, R. 2008. "Sociolinguistics and sociology of language". In B Spolsky and FM Hult, (eds). *Handbook of Educational Linguistics*. Malden, Massachusetts, USA. Blackwell.

International Baccalaureate. 2009. MYP *Language A guide*. Cardiff, UK. International Baccalaureate.

Moje, EB. 2007. "Developing socially just subject-matter instruction: A review of the literature on disciplinary literacy teaching". *Review of Research in Education*. Vol 31. Pp 1–44.

Morrell, E. 2002. "Toward a critical pedagogy of popular culture: Literacy development among urban youth". *Journal of Adolescent & Adult Literacy*. Vol 46. Pp 72–77.

National Council of Teachers of English (NCTE). 2007. *Adolescent Literacy: A Policy Research Brief*. Urbana, Illinois, USA. NCTE.

Selman, RL. 2003. *The Promotion of Social Awareness: Powerful Lessons from the Partnership of Developmental Theory and Classroom Practice*. New York, USA. Russell Sage.

Sleeter, C. 2005. *Un-standardizing Curriculum: Multicultural Teaching in the Standards-based Classroom*. New York, USA. Teachers College.

Solano-Flores, G. 2006. "Language, dialect, and register: Sociolinguistics and the estimation of measurement error in the testing of English language learners". *Teachers College Record*. Vol 108, number 11. Pp 2354–2379.

Appendix 1: Explicit instruction in vocabulary, reading and writing

Deshler, DD, Palincsar, AS, Biancarosa, G and Nair, M. 2007. *Informed Choices for Struggling Adolescent Readers: A Research-Based Guide to Instructional Programs and Practice*. New York, USA. International Reading Association.

Kamil, ML, Borman, GD, Dole, J, Kral, CC, Salinger, T and Torgesen, J. 2008. *Improving Adolescent Literacy: Effective Classroom and Intervention Practices*. *A Practice Guide*. Washington, DC, USA. National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, US Department of Education.

Moje, EB and Speyer, J. 2007. "The reality of challenging texts in high school science and social studies: How teachers can mediate comprehension". In K Hinchman and H Thomas, (eds). *Best Practices in Adolescent Literacy Instruction*. New York, USA. The Guilford Press. (Instructional text)

Explicit vocabulary instruction

Beck, IL, McKeown, MG and Kucan, L. 2002. *Bringing Words to Life: Robust Vocabulary Instruction*. New York, USA. The Guilford Press.

Kelley, JG, Lesaux, NK, Kieffer, MJ and Faller, SE. 2010. "Effective academic vocabulary instruction in the urban middle school". *The Reading Teacher*. Vol 64, number 1. Pp 5–14.

Stahl, SA and Nagy, WE. 2006. *Teaching Word Meanings*. Mahwah, New Jersey, USA. Lawrence Erlbaum Associates.

Explicit instruction in reading comprehension

Kletzien, SB. 2009. "Paraphrasing: An effective comprehension strategy". *The Reading Teacher*. Vol 63, number 1. Pp 73–77. (Research and instructional article)

O'Connell King, K. 2010. *Using Young Adult Literature and Literary Theory to Teach Middle School Students How to Read Through Critical Lenses*. San Rafael, California, USA. Dominican University of California. (Master's thesis)

Sweet, AP and Snow, CE. 2003. *Rethinking Reading Comprehension*. New York, USA. The Guilford Press.

Explicit instruction in writing

Graham, S and Perin, D. 2007. "Writing next: Effective strategies to improve writing of adolescents in middle and high schools—A report to Carnegie Corporation of New York". Washington, DC, USA. Alliance for Excellent Education. (Research synthesis)

Parr, J and Limbrick, L. 2010. "Contextualising practice: Hallmarks of effective teachers of writing". *Teaching and Teacher Education*. Vol 26, number 3. Pp 583–590. (Research article)

Saddler, B and Graham, S. 2005. "The effects of peer-assisted sentence combining instruction on the writing performance of more and less skilled young writers". *Journal of Educational Psychology*. Vol 97. Pp 43–54. (Research article)

Sandmann, A. 2006. "Nurturing thoughtful revision using the focused question card strategy". *Journal of Adolescent and Adult Literacy*. Vol 50, number 1. Pp 20–28. (Instructional article)

Appendix 2: Supporting high-quality, text-based discussions that foster textual understanding

Research suggests that rich discussion is often text-based (Langer 2001; Murphy et al 2009). Engaging in pre-reading prior to discussion creates common background knowledge that can support students in the course of discussion. Given the need to foster perspective-taking through discussion, texts must be selected that create opportunities for students to assume opposing viewpoints (Langer 2001; Reznitskaya et al 2001; Murphy et al 2009). In many instances, students may need to engage with numerous texts to understand the multiple perspectives that exist on a particular issue. These texts serve as "evidence" that students can use to support their own assertions in the course of a discussion. To help students become accustomed to using "reasoned arguments", effective discussions require students to refer to the text to support their arguments (Reznitskaya et al 2001).

Adler, M and Rougle, E. 2005. *Building Literacy Through Classroom Discussion: Research-Based Strategies for Developing Critical Readers and Thoughtful Writers in Middle School*. New York, USA. Scholastic. (Instructional text)

Applebee, AN. 1996. *Curriculum as Conversation: Transforming Traditions of Teaching and Learning*. Chicago, Illinois, USA. University of Chicago Press. (Instructional text)

Applebee, AN, Langer, JA, Nystrand, M and Gamoran, A. 2003. "Discussion-based approaches to developing understanding: Classroom instruction and student performance in middle and high school English". *American Educational Research Journal*. Vol 40, number 3. Pp 685–730. (Research study)

Holden, J and Schmit, JS, (eds). 2002. *Inquiry and the Literary Text: Constructing Discussions in the English Classroom*. Urbana, Illinois, USA. National Council of Teachers of English. (Instructional text)

Langer, JA. 2001. "Beating the odds: Teaching middle and high school students to read and write well". *American Educational Research Journal*. Vol 38, number 4. Pp 837–880. (Research and instructional article)

Murphy, P, Wilkinson, IG, Soter, AO, Hennessey, MN and Alexander, JF. 2009. "Examining the effects of classroom discussion on students' comprehension of text: A meta-analysis". *Journal of Educational Psychology*. Vol 101, number 3. Pp 740–764. (Research synthesis)

Reznitskaya, A, Anderson, RC, McNurlen, B, Nguyen-Jahiel, K, Archodidou, A and Kim, S. 2001. "Influence of oral discussion on written argument". *Discourse Processes*. Vol 32, numbers 2 and 3. Pp 155–175. (Research article)

Collaborative reasoning

In collaborative reasoning, teachers are trained to follow certain guidelines to:

- ask questions of students that require them to explain their positions and to use evidence to support their statements
- model the development of counter-arguments through think-alouds
- recognize and model logical reasoning in the course of the discussion
- summarize the discussion at the end.

The goal of collaborative reasoning is not to reach a consensus but to hear a number of viewpoints. Generally, collaborative reasoning is used with non-fiction texts.

Reznitskaya, A, Anderson, RC, McNurlen, B, Nguyen-Jahiel, K, Archodidou, A and Kim, S. 2001. "Influence of oral discussion on written argument". *Discourse Processes*. Volume 32, numbers 2 and 3. Pp 155–175. (Research article)

Questioning the author

The standard format for questioning the author involves five questions. Students generally read a selection of text (one or more paragraphs) and then answer the following questions in small groups.

1. What is the author trying to tell you?
2. Why is the author telling you that?
3. Does the author say it clearly?
4. How could the author have said things more clearly?
5. What would you say instead?

Beck, IL and McKeown, MG. 2006. *Improving Comprehension with Questioning the Author: A Fresh and Expanded View of a Powerful Approach*. New York, USA. The Guilford Press. (Research and instructional text)

Appendix 3: Teaching to foster genre knowledge and audience awareness

Knowing how texts are constructed supports both reading comprehension and writing in adolescents. Teaching students to identify text structures is an important facet of developing genre knowledge. Importantly, each text structure (such as cause and effect or description) is indicated by a particular structure and by the use of key words such as "because", "therefore", "also" and so on.

Harris, VJ. 2008. "Selecting books that children will want to read". *The Reading Teacher*. Vol 61, number 5. Pp 426–430. (Instructional article)

Letcher, M. 2010. "Off the shelves: Poetry and verse novels for young adults". *English Journal*. Vol 99, number 3. Pp 87–90. (Instructional article)

MacArthur, CA and Philippakos, Z. 2010. "Instruction in a strategy for compare-contrast writing". *Exceptional Children*. Vol 76, number 4. Pp 438–456. (Instructional article)

Montelongo, J, Herter, RJ, Ansaldo, R and Hatter, N. 2010. "A lesson cycle for teaching expository reading and writing". *Journal of Adolescent & Adult Literacy*. Vol 53, number 8. Pp 656–666. (Instructional article)

Neufeld, P. 2005. "Comprehension instruction in content area classes". *The Reading Teacher*. Vol 59, number 4. Pp 302–312. (Instructional article)

Ogle, D and Blachowicz, CLZ. 2002. "Beyond literature circles: Helping students comprehend informational texts". In CC Block and M Pressley, (eds). *Comprehension Instruction: Research-Based Best Practices*. New York, USA. The Guilford Press. (Instructional article)

Orange, C and Horowitz, R. 1999. "An academic standoff: Literacy task preferences of African American and Mexican American male adolescents versus teacher-expected preferences". *Journal of Adolescent & Adult Literacy*. Vol 43, number 1. Pp 28–39. (Research article)

Appendix 4: Teaching to foster argumentation skills

In this discussion, argumentation refers to using reasoned arguments to support one's thinking. This skill is foundational to successfully writing a literary analysis or to writing a well-reasoned academic paper. In both instances, students are asked to engage academic language to communicate an epistemic stance. Thus, later academic language use can be viewed as primarily argumentative.

Kuhn, D. 1991. *The Skills of Argument*. Cambridge, UK. Cambridge University Press. (Instructional text)

Nussbaum, EM and Schraw, G. 2007. "Promoting argument-counterargument integration in students' writing". *Journal of Experimental Education*. Vol 76, number 1. Pp 59–92. (Research and instructional article)

Wiley, J and Voss, JF. 1999. "Constructing arguments from multiple sources: Tasks that promote understanding and not just memory for text". *Journal of Educational Psychology*. Vol 91, number 2. Pp 301–311. (Research and instructional article)

Yeh, S. 1998. "Empowering education: Teaching argumentative writing to cultural minority middle-school students". *Research in the Teaching of English*. Vol 33. Pp 49–83. (Instructional article)

Appendix 5: Literacy instruction that considers what motivates adolescents

Fostering school-based communicative competence is the ultimate goal of English language arts (ELA) instruction; but this instruction should acknowledge that diverse learners are competent communicators in the discourse communities in which they live. Thus, the task is to develop new learning using existing competencies and to build on students' interests (from the MYP *Language A guide* (2009)) and the National Council of Teachers of English (NCTE) *Adolescent Literacy* policy research brief). Furthermore, research suggests instruction that is motivating engages adolescents by helping them to make personal connections to the instructional content. This suggests that instruction must take into account the cultural, ethnic/racial and developmental identities of the adolescent learners in language A classrooms. Recent theoretical literature on the topic of multicultural education suggests that if instruction is truly culturally relevant it must create opportunities for students to reflect on the nature of social inequality. These social justice pedagogies have been dubbed "critical literacy" and "new literacy studies". Such rich instructional content provides students with opportunities to discuss their own thinking and to hear how others view and understand the course content.

Cammarota, J. 2007. "A social justice approach to achievement: Guiding Latina/o students toward educational attainment with a challenging, socially relevant curriculum". *Equity and Excellence in Education*. Vol 40. Pp 87–96. (Instructional article)

Gay, G. 2000. *Culturally Responsive Teaching: Theory, Research and Practice*. New York, USA. Teachers College Press. (Instructional text)

Kumashiro, K, (ed). 2001. *Troubling Intersections of Race and Sexuality: Queer Students of Color and Anti-Oppressive Education*. Lanham, Maryland, USA. Rowman and Littlefield. (Research and instructional text)

Ladson-Billings, G. 1994. *The Dreamkeepers: Successful Teachers of African American Children*. San Francisco, California, USA. Jossey-Bass. (Instructional text)

Lapp, D and Fisher, D. 2009. "It's all about the book: Motivating teens to read". *Journal of Adolescent & Adult Literacy*. Vol 52, number 7. Pp 556–561. (Research and instructional article)

Lenters, K. 2006. "Resistance, struggle, and the adolescent reader". *Journal of Adolescent & Adult Literacy*. Vol 50, number 2. Pp 136–146. (Research and instructional article)

Moje, E and Hinchman, K. 2004. "Culturally responsive practices for youth literacy learning". In T Jetton and A Dole, (eds). *Adolescent Literacy Research and Practice*. New York, USA. The Guilford Press. (Research and instructional article)

Nieto, S. 2000. *Affirming Diversity: The Sociopolitical Context of Multicultural Education, Third Edition*. New York, USA. Longman. (Research and instructional text)

Palincsar, AS and Herrenkohl, LR. 2002. "Designing collaborative learning contexts". *Theory into Practice*. Vol 41, number 1. Pp 26–32. (Instructional article)

Research suggests that culturally responsive educators strive to engage diverse students by situating them as "funds of knowledge" within the classroom (Ladson-Billings 1994; Gay 2000; Nieto 2000; Moje and Hinchman 2004). This creates a context where students are more likely to engage in literacy and learning activities. In practice, this could include asking students to share their personal connections to texts read in class and selecting texts that include diverse protagonists (Nieto 2000; Moje and Hinchman 2004). Such instructional practices complement the way in which language is viewed within the larger International Baccalaureate instructional framework.

Motivation and engagement underpin school/language A success

Research has found that motivation is central to reading success. Given this, instructional and classroom practices must seek to foster student motivation by providing meaningful learning opportunities. Developmental research suggests that adolescents are largely preoccupied with social elements of the instructional context and that effective literacy instruction incorporates this interest to foster student engagement, motivation and resilience (Moje et al 2008). Motivation and engagement, although interrelated, are distinct (Kamil et al 2008). Motivation refers to the interest or desire that students may have in engaging with a reading task. Engagement, on the other hand, refers to the deep processing of texts by students when using reading strategies (Kamil et al 2008). Thus, engagement is connected with having the process and background knowledge to gain meaning from a reading task.

Anderson, A, Hamilton, R, Hattie, R. 2004. "Classroom climate and motivated behaviour in secondary schools". *Learning Environments Research*. Vol 7, number 3. Pp 211–225. (Research study)

Kamil, ML, Borman, GD, Dole, J, Kral, CC, Salinger, T and Torgesen J. 2008. *Improving Adolescent Literacy: Effective Classroom and Intervention Practices. A Practice Guide*. Washington, DC, USA. National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, US Department of Education.

Moje, E, Overby, M, Tysvaer, N and Morris, K. 2008. "The complex world of adolescent literacy: Myths, motivations, and mysteries". *Harvard Educational Review*. Vol 78, number 1. Pp 107–154. (Research study)

Cultivating interest in reading tasks

These authors suggest that by connecting texts and reading tasks to students' larger goals and aspirations, teachers can foster motivation. Additionally, choosing texts that are appropriately levelled can increase motivation.

Activating students' background knowledge before reading, modelling comprehension-monitoring strategies and encouraging students to use the text when answering comprehension questions are all strategies that help to support student success with reading tasks and, as a result, to foster motivation.

Gaskins, IW. 2005. *Success with Struggling Readers: The Benchmark School Approach*. New York, USA. The Guilford Press. (Instructional text)

Guthrie, JT, Wigfield, A and Perencevich, KC. 2004. *Motivating Reading Comprehension: Concept-Oriented Reading Instruction*. Mahwah, New Jersey, USA. Lawrence Erlbaum Associates. (Instructional text)

Schunk, DH. 2003. "Self-efficacy for reading and writing: Influence of modelling, goal setting, and self-evaluation". *Reading & Writing Quarterly*. Vol 19, number 2. Pp 159–172. (Research study)

Resilience

Cappella, E and Weinstein, RS. 2001. "Turning around reading achievement: Predictors of high school students' academic resilience". *Journal of Educational Psychology*. Vol 93, number 4. P 758. (Research study)

Lenski, S and Lewis, J. 2008. *Reading Success for Struggling Adolescent Learners. Solving Problems in the Teaching of Literacy*. New York, USA. The Guilford Press. (Instructional text)

McTigue, EM, Washburn, EK and Liew, J. 2009. "Academic resilience and reading: Building successful readers." *The Reading Teacher*. Vol 62, number 5. Pp 422–432. (Research study and instructional suggestions)

Appendix 6: Assessing language use

Formative assessment

Formative assessment refers to the frequent assessments of student progress and understanding as a method to identify learning needs and adjust teaching appropriately.

Andrade, Buff, Terry, Erano and Paolino (2009) found that the use of formative assessment practices in language arts classrooms, including rubrics, led to improved student performance on summative writing assessments in this small-scale study of 6th, 7th and 8th graders at an urban middle school. Also, the authors reported that students were more able to accurately self-assess and evidenced more positive feelings about writing after formative assessment was implemented.

Andrade, H, Buff, C, Terry, J, Erano, M and Paolino, S. 2009. "Assessment-driven improvements in middle school students' writing". *Middle School Journal*, Vol 40, number 4. Pp 4–12. (Research article)

Brookhart, S. 2008. "Feedback that fits". *Educational Leadership*. Vol 65, number 4. Pp 54–59. (Instructional article)

Fisher, D and Frey, N. 2007. *Checking for Understanding: Formative Assessment Techniques For Your Classroom*. Alexandria, VA, USA. Association for Supervision and Curriculum Development. (Instructional text)

Marzano, R. 2009. "When students track their progress". *Educational Leadership*, Vol 67, number 4. Pp 86–87. (Research article)

Organisation for Economic Co-operation and Development (OECD). 2005. *Formative Assessment: Improving Learning in Secondary Classrooms*. Paris, France. OECD Publishing. (Research study)

Summative assessment

Summative assessment refers to those benchmarking tests that are given to evaluate students' progress. Importantly, standards-based education has resulted in a hyper-focus on such assessments and a subsequent backlash from educators. Importantly, such assessments can provide valuable information about student progress and, as noted above, can be used formatively.

Assessing speaking/discussion

Alexander, R. 2006. *Towards Dialogic Thinking: Rethinking Classroom Talk*. York, UK. Dialogos. (Theoretical text)

Frazier, C. 1997. "The development of an authentic assessment instrument: The scored discussion". *English Journal*. Vol 86, number 1. Pp 37–40. (Instructional article)

Assessing written productive and receptive communicative skills: Reading, writing

Dawson, CM. 2009. "Beyond checklists and rubrics: Engaging students in authentic conversations about their writing". *English Journal*. Vol 98, number 5. Pp 66–71. (Instructional article)

Graziano-King, J. 2007. "Assessing student writing: The self-revised essay". *Journal of Basic Writing*. Vol 26, number 2. Pp 75–94. (Research study)

Spence, LK. 2010. "Discerning writing assessment: Insights into an analytical rubric". *Language Arts*. Vol 87, number 5. Pp 337–352. (Instructional article)

How can we best teach new languages? Considering core principles in language B instruction

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Learning world languages enables us to have access to new communication systems and to gain a deeper understanding of other cultures, which can potentially serve as a basis for a more harmonious communication between communities, and even nations. Our present world is marked by unprecedented and increasing coexistence and interactions among speakers from different languages and cultures owing to migration and globalization. Given increasingly diverse local contexts and global networks, the International Baccalaureate (IB) recognizes the special urgency of developing more interculturally competent societies and thus the importance of a comprehensive approach to teaching foreign languages (language B). The IB seeks to prepare students to become advanced language users while simultaneously nurturing a genuine curiosity about, and a respectful insight into, the experiences, lifestyles, perspectives and accumulated knowledge of the communities where the languages are spoken. Within this comprehensive approach to language B, optimal instruction involves more than fostering technical proficiency in grammar and vocabulary; it includes promoting communication skills, understanding the new language as a rich source to scaffold learners' understanding, respect and appreciation of other cultures, as well as a source to promote students' reflective stance towards their own language and culture.

Over the last decades, several organizations have articulated extensive sets of foreign language goals accompanied by specific instructional recommendations to address each goal. Expert organizations and entities, such as the American Council on the Teaching of Foreign Languages (ACTFL) and the College Board, offer helpful resources and materials addressing curricular goals and instruction. In this chapter, we seek to move beyond previous reports by offering educators a concise explanation of how language works and how language learning takes place. Specifically, we focus on four big ideas or core principles shaping language B mastery: context, culture, reflection and fluency. These principles serve as a rationale for a quality approach to language B instruction in the IB. Such a quality approach moves away from teaching grammar as a set of independent and disconnected skills and emphasizes an integrated set of languages skills connected with specific purposes, contexts and content in a manner that leads to intercultural sensitivity as well as fluency and reflection on language. Ultimately, high-quality teaching of language B requires a reflective approach to instruction: Why does learning a language other than one's own matter, after all? What matters most to teach about language B? What learning challenges does learning language B present to students? How might we design instruction in ways that enable students to achieve high levels of language proficiency?

In the next sections of this chapter we briefly articulate the significance of language B instruction for today's youth. After a brief discussion of the current comprehensive approaches to foreign language instruction currently guiding the field, we present and describe four core principles of language B teaching and learning. Finally, we present some challenges inherent to the language B classroom and offer some recommendations.

Why does language B learning matter today?

Contrary to the belief of some people, the world is predominantly multilingual; monolingualism is actually the rare case, not the norm. In the context of unprecedented waves of migration, multilingualism is becoming more prominent, and international organizations and corporations are more prevalent than ever. International organizations, such as UNESCO and the European Council, and national associations, such as the American Council on the Teaching of Foreign Language in the United States, have eloquently argued for language proficiencies as highly relevant career and civic participation skills in a world where the ability

to interact, study and work with people different from ourselves is an increasingly salient advantage in the educational, civic and professional realms.

A new language provides an entry into an alternative communication system and a new way of making sense of the world. Speaking a new language enables us to interact with people who are different from those usually closer to us and enables us to become potential bridges between people who cannot comprehend one another. Understanding materials written in another language opens a door into the accumulated knowledge, experiences, histories and wisdom of communities other than our own. This, in turn, offers an opportunity to understand multiple cultures, with the possibility of reaching a deeper understanding of others and ourselves in the world.

A new language also enables ongoing learning with important potential cognitive benefits. For example, Ellen Bialystok's research has documented the cognitive benefits of fluent bilingual speakers, reporting that bilingual individuals have lasting advantages in metalinguistic awareness (the capacity to reflect about how language works) and cognitive flexibility (moving across competing input or ideas) when compared to monolingual speakers. Recent research has also documented academic achievement benefits with United States elementary school students who received second language instruction outperforming their peers in standardized assessments of English language, arts, mathematics, science and social studies (Taylor, Lafayette 2010).

Reaping some or all the benefits of learning a language other than one's own depends, of course, on the way language B instruction is conceptualized and delivered—that is, the dimensions of language that are emphasized, as well as the instructional approaches of choice. In the next section, we specify the goals of language B education and, subsequently, propose four core principles for informing a curriculum that maximizes the learning opportunities in foreign language classrooms.

What are the curricular goals of a comprehensive language B approach?

The primary aim of language B in the Middle Years Programme (MYP) is to encourage students to gain competence in a modern language other than their mother tongue, with the purpose of achieving long-term and "deep translingual and transcultural competence" (Modern Language Association 2007). The IB acknowledges that learning additional languages greatly contributes to the holistic development of students. Proficiency in a second language gives students access to a broader range of input, experiences and perspectives, and is believed to raise achievement in other subject areas, as well as giving the student the enjoyment of being able to communicate in a language other than his or her mother tongue. The study of MYP language B aims to encourage in the student a respect for, and understanding of, other languages and cultures, and to provide a skills base to facilitate further language learning. The language B aims are in line with the approaches and curricular goals proposed by other leading organizations, such as ACFTL and the Modern Language Association (MLA).

According to the *National Standards for Foreign Language Education* (NSFLE) supported by ACTFL, the goal of foreign language education is to "**know how, when, and why to say what to whom**". The following paragraph captures the innovation of a NSFLE programme focused on language mastery as communication.

> Formerly, most teaching in foreign language classrooms concentrated on the **how** (grammar) to say **what** (vocabulary). While these components of language are indeed crucial, the current organizing principle for new language study is **communication**, which also highlights the **why**, the **whom**, and the **when**.

> So, while grammar and vocabulary are essential tools for communication, it is the acquisition of the ability to communicate in meaningful and appropriate ways with users of other languages that is the ultimate goal of today's foreign language classroom.
>
> (*NSFLE* 1999: 1)

As most foreign language educators know, this overarching goal for foreign language instruction has been disaggregated into the five Cs: communication, cultures, connections, comparisons and communities. (For a description of each of the five Cs, see "Appendix 1: The five Cs of foreign language education").

Building on such a communicative approach to language instruction, the MLA states the objectives of college foreign language education as follows.

> In the course of acquiring functional language abilities, students are taught critical language awareness, interpretation [...[2]], historical and political consciousness, social sensibility, and aesthetic perception.
>
> (MLA 2007: 5)

Such comprehensive conceptualization of language B instruction moves beyond teaching separate language skills to reframe the responsibility of language B educators and curriculum designers as one of teaching language as embedded in the larger enterprise of fostering an understanding of the social perspective of the native speakers of such language, their history, political circumstances, social structures and artistic contributions. Whereas during the college years students will certainly be able to acquire more mature critical and reflective understandings, students in the MYP are uniquely positioned to be guided by these same comprehensive and ambitious objectives if the goal is to promote efficient language uses and intercultural sensitivity.

When experienced teachers are informed by such a comprehensive approach, they think about languages as more than grammar and vocabulary. They view languages as a social phenomenon, inseparable from context. Such an approach allows language B teachers to enjoy a new focus on culture and contexts, which adds new interesting content to their curriculum and considerable freedom about the kinds of substantive themes they will use to enhance their students' communicative skills. However, the opportunities embodied in a more comprehensive approach to foreign language instruction also present important challenges. Experienced teachers puzzle about how to choose from the now longer list of skills contained in their yearly plans or how to possibly cover them all—from basic vocabulary to intercultural skills. Others worry, rightly, that their thematically engaging lessons may ultimately not yield language proficiency, nor a deep understanding of how language works. With so much to learn about a foreign language, so many interesting topics to discuss and so little time to do so, teachers' concerns beg the question: What matters most to learn about an additional language? If there were a few core principles along which teachers could design their instruction in order to unlock students' capacity to perform in a variety of non-native language contexts, what would these domains be?

In the following section, we draw from current standards of foreign language education and research on language learning to propose four core principles of language teaching and learning. Our proposed approach is in line with the conceptualizations of foreign language education discussed above, by moving away from teaching languages only as **linguistic systems** of words and grammar and, instead, promoting the development of **high language proficiency** and **intercultural sensitivity**.

Core domains in mastering a new language

Drawing from research on first and foreign language learning, we outline the following four core domains of language mastery, by which we mean both oral and written proficiency. These four domains entail a reframing of the NSFLE five Cs in an effort to complement the NSFLE position with an informed

[2]We have omitted the word "translation" from this quote as this is a specific objective and trajectory students might choose during the college years, but it is not an objective during the Middle Years Programme.

understanding of how language works and how language mastery unfolds. We firmly believe that such holistic understanding is highly relevant to guide advanced learning and teaching in an optimal manner. The four core principles are briefly outlined below.

1. **Context:** Successful communication depends on purpose, content and context. Context-relevant language use requires learning for different purposes in different social settings. (NSFLE: Communication)
2. **Culture:** Culturally informed language use requires learning and understanding the cultural conventions and the cultural knowledge associated with the language.
    a. **Culturally sensitive language use** entails understanding the cultural lifestyles, behaviours, beliefs and values of native speakers. (NSFLE: Cultures)
    b. **Cultivated language use** rests on understanding cultural legacies and accumulated historical, literary and artistic knowledge associated with the language. (NSFLE: Connections)
3. **Reflection:** Reflective language use involves contrasting different languages, cultural lifestyles and cultural products to understand multiple world views. (NSFLE: Comparisons)
4. **Fluency:** Fluent, context-relevant, culturally informed and reflective language uses require understanding that meaningful and abundant practice is indispensable to achieve optimal levels of language B mastery. (NSFLE: Communities)

These core principles of language mastery offer central pillars for a curriculum organized to develop high levels of foreign language proficiency over time and provide a rationale for why language learning and teaching ought to proceed in a comprehensive, integrated manner to achieve optimal outcomes. The principles closely align with the IB curricular aims and also with the goal of foreign language instruction as currently defined by the National Standards in Foreign Language Education (1999).

The four core domains proposed here are to be considered together as teachers help students achieve high proficiency in using a language for multiple purposes—from making a polite request to defending a point of view in a written argument about a controversial global issue. To engage language B learning in such a purposeful manner, the following questions—written from the students' perspective—are helpful to design curriculums and implement particular lessons.

1. **Context**

    For what purpose, to address which audience and in what context am I using the language?

    What vocabulary, grammatical and discourse forms do I need to learn to use language successfully for such a purpose, audience and context?

2. **Culture**

    What cultural knowledge is crucial and desirable for using language successfully in this context?

    a. What are the conventions of acceptable cultural behaviour? What values, beliefs and traditions do I need to be aware of in this context?
    b. What bodies of knowledge and cultural references are relevant for a well-informed use of language in this context?

3. **Reflection**

    Are language structures, cultural lifestyles or cultural perspectives different from those of my community?

    a. If so, how can I reflect upon similarities and differences in a way that would lead to linguistic and cultural awareness?
    b. How can these reflections move me beyond stereotypes and lead me to an appreciation of alternative ways of communicating and making sense of the world?

4. **Fluency**

   How can I best practise the language skills learned for this context?

   a. What are scenarios that can be recreated in the classroom to promote authentic and meaningful uses of language?

   b. What opportunities outside the classroom can be incorporated to further expand the authentic uses of the language?

Keeping in mind that the four core principles are to be considered in synchrony, as suggested by the above set of questions, we now focus on each principle separately in order to explain in more depth what each one entails.

Towards a curriculum informed by language B core principles

Context: Language mastery entails context-relevant uses of language

Successful use of language relies on mastering not only vocabulary and grammar but larger constellations of skills that vary by context.

The key notion here is that different uses of language for particular purposes and contexts require, and are shaped by, different subsets of language skills and goals of communication. Two key constructs are: **genres** or **types of texts** (for example, personal narrative, picture description or persuasive essay) and **register** (for example, formal versus informal register). Teachers are usually aware that the colloquial skills for successful communication at a restaurant or airport are somewhat different from those required for academic tasks and, consequently, need to be scaffolded independently.

Aligned with the new framework advanced by ACTFL and adopted by the College Board, this view goes beyond the traditional division between comprehension and production by stressing the context of language use. In this way, face-to-face communication (interpersonal mode) requires different skills from those needed in interpreting a text or a speech (interpretive mode) or for producing an academic presentation or essay (presentational mode) (American Council on the Teaching of Foreign Languages 1998; Glissan et al 2003; MLA 2007).

However, it is necessary to further highlight that within the informal and formal registers and within the different modes of communication, specific uses of language—such as writing a persuasive essay versus a movie review—also require slightly different sets of skills and, therefore, students will benefit from targeted, specific and repeated attention to particular types of texts.

For instance, telling a personal narrative will require different language skills to describing a painting. In personal narratives, action verbs, past tense and temporal connectives (for example, "after" or "subsequently") need to be used effectively, whereas in the description of a painting, verbs of state, present tense and spatial connectors (for example, "above" or "surrounding") are more salient. Analogously, different types of texts call for different characteristic expressions. For example, a fairy tale demands conventional beginnings (for example, "*Había una vez*"/"Once upon a time") that are different from those of a personal anecdote (for example, "*Te cuento que …*"/"Let me tell you something …"). Different purposes require different kinds of vocabulary, expressions and grammatical skills. Therefore, a focus on scaffolding the mastery of larger units of formal or informal discourse will help students put the vocabulary and grammar to the service of particular purposes.

How can teachers nurture students' capacity to see that the vocabulary, grammar and language forms they learn are not isolated pieces of information to be memorized (for example, as a list of fruits, body parts or a fixed conversational sequence) but rather that they constitute a toolkit from which to draw for multiple contexts and purposes? To design effective instruction, teachers can:

- focus on a selection of particular uses of language for a unit (presenting literary analysis, rallying community support, writing an opinion article).
- specify the language objectives that are essential to produce such uses of language and can discuss the content objectives of the unit.

In addition, particular uses of language, with their corresponding language forms, need to be coordinated across units, so that teachers provide students with multiple opportunities to practise forms in specific registers and text types (for example, subjunctive forms of verbs of influence in formal persuasive essays) as they engage in the exploration of meaningful questions.

It is important to point out also that an integrated approach does not preclude in any way the explicit teaching of vocabulary and grammar. In the context of providing extensive practice through authentic activities, explanation of vocabulary, explicit mini lessons or implicit exercises to scaffold grammar are key to improving proficiency and should ideally constitute a regular part of instruction. The current disagreements in the field of foreign language instruction are not whether to teach grammar or not, but whether to teach it explicitly or implicitly. Katz and Blyth (2007) propose the following three questions to guide instructors' decisions on whether, and how, to focus on grammar.

1. Is this form [of language] amenable to instruction?
2. Can this form be learned without pedagogical intervention?
3. What combination of implicit and explicit techniques gives the best results?

Far from being mutually exclusive, grammar and communicative skills can be taught together. That is, in fact, the way in which we all communicate: by selecting appropriate vocabulary and grammar to fulfill our communicative needs. Optimal grammar instruction will draw "students' attention to a linguistic form in real communicative context" (Katz, Blyth 2007: 16). It is precisely because a learner needs to use a form that he or she will be motivated to learn it, find it relevant to produce the accurate form, and encounter the opportunities to practise the recently acquired knowledge in authentic situations.

Thinking of language as context-dependent invites teachers to reframe their beliefs about what it means to gain second language proficiency. From this standpoint, students advance not only **vertically** (from low to high proficiency) but also **horizontally**, through the gradual mastery of the language skills required in an increasing set of communicative contexts (European Framework 1996). Given that a language B curriculum cannot possibly cover the full range of contexts, teachers must prioritize those that will most benefit students given the programme's goals and expectations on language use.

Culture: Language mastery entails culturally informed uses of language

Culturally sensitive language use rests on understanding the cultural practices, beliefs, values and lifestyles of native language speakers. Cultivated language use requires knowledge of the histories, geographies, literatures, art and knowledge associated with the language.

Understanding the conventions and limits of acceptable cultural behaviour is critical for effective language use. As pointed out in our introductory section, participating effectively and appropriately in a language community other than one's own involves more than just language forms. It involves understanding some of the cultural norms, behaviours, beliefs and ways of communicating associated with the new language.

Learning about the cultural conventions and beliefs that guide the limits of acceptable behaviour is essential to functioning successfully when interacting with language B interlocutors. For example, it would be highly inconvenient to not know whether the native speakers of language B tend to greet one another with a shake of the hand, one kiss, two, or even three, kisses. Some cultural traditions are directly reflected in language choices and behaviours. For example, Spanish-speaking countries in which dinner typically takes place after 9:00pm do not distinguish between "Good evening" and "Good night" as English speakers do. "*Buenas noches*" is used appropriately in both cases. Conversational turn-taking is another case in point. Spanish speakers usually consider their turn to end when another speaker initiates a sentence, with frequent overlaps across speakers' turns. English speakers understand this to be a rude interruption, since they view the end of a conversational turn to be when the speaker concludes his or her claim. In academic discourse, Spanish and French academic writing tends to leave the core argument for the end of an essay or paper, whereas English forms of persuasion favour presenting the core of an argument upfront. Another useful domain of contrast in both content and language choices across languages/cultures is politeness, for example, in how to offer an apology to a university professor; in using "please" and "thank you" in different situations, which varies considerably across languages or language varieties. Learning to participate in multiple linguistic communities appropriately involves grasping the cultural dimensions of language and, fundamentally, learning that language communities have distinctive ways of doing things.

Furthermore, when speakers become more educated members of society, they increasingly rely on shared socio-historical, political, cultural or geographical knowledge related to the past and present of their societies. This knowledge is learned and used particularly, but not exclusively, in educational, institutional or professional contexts. Not being aware of the relevant references (for example, pop culture in talking to adolescent speakers; historical events in discussing the daily national news; geographical landmarks in reading historical fiction; major well-known artists in a casual conversation) can lead to failure in communication despite skilled mastery of vocabulary and grammar. Effective language B teaching provides students with sufficient and varied historical and cultural knowledge to participate in well-informed discussions and critical analyses of the themes addressed in a unit or project—whether the unit is about travel, current events, the environment or cultural practices.

Traditional language B curriculums address this principle, but often only partially. Language B lessons frequently incorporate only mainstream practices and literary texts that are viewed as hallmarks of the behaviours and knowledge produced by a culture. An important consideration, however, is to expand the range of materials so that not only mainstream conventions and the traditional canonical works of art and literature are represented, but also a variety of speakers' perspectives (youth, immigrant, political groups), disciplines (history, political science, economics), types of texts (political speeches, comics, opinion articles, ecological reports, literary classics), and various media (books, songs, videos, electronic texts). A multitude of texts in various formats offer multiple entry points on a common theme for students with diverse interests. A more diverse repertoire of perspectives would ideally provide "windows and mirrors" into students' lives to enable them to look through windows at the lives of others and to see themselves reflected in mirrors that are closer to their own lives (Style 1996). The representation of alternative perspectives also presents communities of native speakers as the dynamic, multidimensional entities they are, instead of offering a superficial fixed portrait of a selected dominant side of society. The design of meaningful contexts to integrate a selection of materials that provide key knowledge on geographical, historical, political and artistic dimensions of a motivating and relevant question for inquiry provides an optimal setting to engage students in active reading, reflective analysis, high-quality oral discussions or debates, and committed writing.

Reflection: Language mastery entails reflective uses of language

Reflective language use entails deepening linguistic and intercultural sensitivity. In other words, it entails being aware of differences across languages and learning to appreciate cultural beliefs, behaviours, ways of communicating and world views, including one's own, with the ultimate goal of achieving intercultural sensitivity.

Language B classrooms offer ideal environments for students to reflect about similarities and differences between languages, cultural practices and identities, those of others and their own. In learning a new language,

students have the opportunity to contrast language and cultural practices, such as the differences in politeness and turn-taking explained above. By inviting students to reflect on these norms systematically, teachers help them go beyond just knowing that "different people communicate and do things differently than I do", to take them some distance from their own native language and to adopt the perspective of a language B speaker. Through guided instruction and thoughtful explanations, students can gradually understand that the behaviours and expectations familiar to them as users of their native language/culture just appear to be the "natural" or "logical" way to live, but that their native language/culture follows conventions just as any other.

Language B classrooms also offer students an opportunity to examine the perspective of various native speakers situated in specific geographical, historical and sociocultural contexts in ways that help them understand multiple perspectives on common events. For example, students can be guided to understand how a newspaper in the United States can have a radically opposite representation of the same event (for example, the Iraq war or the consideration of Palestine as a new member of the United Nations) when compared to one in Spain or France.

This appreciation for the cultural, political and historical dimensions associated with native speakers of a language enables students to expand their world views. Intercultural sensitivity is enhanced when both our own and others' native languages and cultures are valued, understood and integrated.

How can teachers enable students to enrich their world views and identities through language use? When teachers focus their attention on language B's capacity to enrich students' world views and identities, they often invite students to conduct comparisons of various types. By comparing different behaviours, beliefs and communicative patterns across cultures/languages in given situations, students understand alternative models of behaviour and beliefs. By comparing across cultural products (reports, articles, art) in different cultures, students learn to appreciate different perspectives on common issues, different political ideologies, different aesthetics and different ways of thinking, thus enriching our understanding of human capacities. By using a common entry point, whereby all students can explore a complex concept (for example, "respect", "wedding") that cuts across different languages/cultures, students can build a deeper understanding of multiple points of view including their own. Heritage speakers can contribute greatly to these conversations as they hold a vast reservoir of cultural understanding. In classrooms where language is viewed as an invitation to inquire about other cultures, and one's own, these students come to understand that their often more colloquial language varieties, their cultural patterns, home practices, beliefs and world views are important and valuable.

In summary, when experienced language B teachers invite students to compare two or more languages reflectively, they are enabling them to move from self-referential thinking and stereotypes about others, towards greater intercultural sensitivity (Hammer, Bennett, Wiseman 2003). In other words, these teachers enable students progressively to notice relevant cultural differences and embrace them with comprehension and respect. Researchers studying intercultural sensitivity have characterized students' growing ability as entailing the following progression: from early ethnocentric stages of denial, defence or minimization of difference between one's own and others' cultures, to "ethnorelative" stages in which students tend to accept difference, adapt to it and, finally, integrate cultural norms moving fluently across cultures (Bennett 1998). See "Appendix 2: Intercultural sensitivity and intercultural competences" for more details of this progression.

Fluency: Language mastery entails achieving fluent, context-relevant, culturally informed, reflective uses of language

Fluency in language use entails understanding the centrality of authentic practice inside and outside the language classroom. Language practice is at the core of language learning.

From the beginning phases of language B instruction (we would claim from the very first lesson onwards) through the most advanced courses, practice needs to be at the centre of the enterprise. Even with the most elemental building blocks of language, assignments and activities can be engineered to promote meaningful communication among students. Oral and written practice can continue to be at the pedagogical centre through oral collaborative text-based analyses to achieve deeper interpretations of text,

through high-quality classroom discussions of current events, through cine club activities to review movies, or through debates of controversial issues. At all levels, multiplying the opportunities for students to use language authentically can be achieved: orally, through regular use of partner talk and small-group talk in all classes; and through reading and writing exercises connected to such oral discussions.

Crafting multiple opportunities for students to master the language forms and rhetorical choices required in particular communicative contexts is often overlooked in curricular design. It is important to highlight that nobody learns how to tell a personal story by trying it once. Becoming an increasingly skilled reader and writer of fiction involves abundant active exposure to fictional stories. Becoming a fluent presenter of scientific reports requires extensive practice in this particular context. Learning to rally community support for a given cause requires practice with regular active listening and effective use of persuasive language. Repeated participation in reading, close analysis of text, writing and orally producing each of these types of oral or written discourses will yield success and deep understanding of the conventional forms and stylistic options available for each context-specific communication.

Thus, achieving advanced mastery that leads to fluent context-relevant, culturally sensitive, cultivated, reflective uses of language requires that educators and curriculum experts think about these core principles to tactically select particular uses of language to be fostered through abundant targeted oral and written practices. (For a more concrete illustration of how these principles would inform instructional design, see "Appendix 3".) Such a comprehensive and in-depth approach to language B instruction, of course, involves new challenges for language teaching and learning. Next, we present common challenges teachers face in the classroom along with some recommendations to address them.

What is challenging about developing language mastery within the four principles?

In the previous section, we outlined and illustrated core domains around which the language B curriculum and instruction could be organized. As students move towards higher levels of proficiency in a new language, they face several important learning challenges. Understanding such challenges will enable teachers to design learning experiences that address particularly demanding aspects of learning upfront. To support teachers in their efforts to assess and guide student learning, we describe these challenges briefly and include recommendations about how they might be handled in the language B classroom.

Learning new registers, including academic language

The challenge

Knowing vocabulary and grammatical rules to be able to solve quizzes and complete fill-in-the-blank exercises can only lead to a fragment of the knowledge students need to become successful language users. The authentic measure of language mastery is the efficient use of those forms to solve particular challenges. In the advanced years of language B instruction, students need to master the particular register of school, **academic language**, with increasing accuracy and automaticity.

Recommendations

To address this challenge, effective teachers provide multiple opportunities for students to interpret and express the complex abstract messages required for academic tasks. They lead high-quality, text-based classroom discussions where students are exposed to advanced language in written or oral form (an article, a presentation) and are invited to produce group interpretations. When necessary, teachers serve as bridges, paraphrasers and interpreters of more complex texts, extending students' language abilities by doing so. Additional helpful activities include explicit analysis and contrast of different

texts that discuss the same topic but are addressed to different audiences with different registers, for example, a movie review published in a children's magazine versus one from an academic film journal. Together with the production of texts for two different audiences, such register comparisons help students to connect the relevant language forms and functions with their correspondent registers (Pang 2002).

Students who have mastered the academic register of formal presentations and various writing genres in their first language will be able to transfer many of their skills for organizing academic discourse to the new language. However, some students may not have a foundational mastery of academic language in their first language. In those cases, teachers of language B need to be sensitive to the fact that these students are learning simultaneously a new language and an unfamiliar register. Effective teachers can opt for making the linguistic expectations of their assignments explicit, providing language stems and graphic organizers that can help students to gradually master the conventions and rhetorical options of particular formal genres.

Breadth and depth of language knowledge

The challenge

Beyond the repertoire of simple concrete words, many words, especially in formal settings—academic or literary words—have multiple meanings and connotations that are often hidden to foreign language speakers. Consider the ways in which we naturally learn to master language forms, such as expressions, words, grammatical structures (for example, "bank" as a business as opposed to the "bank" of a river; "bank" as noun or verb). Most commonly, we encounter such forms in context. Even though we may occasionally need a definition, the strength of our vocabulary knowledge stems from seeing and using a word in a variety of slightly different contexts repeatedly. With each opportunity for use, a given word or expression gains a slightly new, nuanced meaning that expands not the number of words, but the depth of knowledge of a particular word. Similarly, when becoming highly proficient in two or more languages, it is not enough to expand vocabulary breadth, that is, to acquire a large repertoire of new words through definitions; vocabulary depth is equally important. Word meanings are learned gradually, exploring semantic associations, connotations, the possible range of syntactic and discourse structures in which words can occur, and so on.

Recommendations

When language B teachers structure their curriculum along the core domains, they invite students to revisit language forms over time. For example, students may revisit how a word (*estación*) may have different meanings in different contexts, they learn some fixed expressions with obscure meanings (*pasar por alto* ***al margen*** *de esta explicación****dar pie a****un discurso*), and be pointed towards words that have positive negative connotations (unusual singular). This form of deliberate instruction gives language B students exposure to hidden layers of meaning that they will not have access to otherwise. However, including these words and expressions in the curriculum is only the first step. Continuous use and "recycling" of such words is the essential complement for a meaningful expansion of rich vocabulary knowledge.

Achieving high levels of intercultural sensitivity

The challenge

When language B teachers focus their instruction on helping students understand that language is a door into cultural legacies, and that by mastering another language they can expand their world view and identity, they are, in essence, inviting students to develop their intercultural sensitivity. Research evidence suggests that language study often fails to alter students' self-referential and stereotypical thinking—or even increases negative views of the culture of the second language they are studying (Swaffar, Arens 2005). It is not uncommon that learning a second language presents students with oversimplified characterizations of the cultures they study (for example, Brazilians are happy and poor, French are educated). These presentations of culture bind individuals into seemingly homogeneous groups,

considered from an omniscient perspective, and do not prepare students to examine how language can express the perspectives of a broad variety of individuals within a cultural group.

Recommendations

To help students overcome stereotypical views of other cultures, effective teachers tend to invite students to consider multiple perspectives on a single topic (for example, cultural icons such as the Eiffel Tower) in ways that reveal the meaning this topic has for various members of the culture (such as the educated Parisian or the first-generation immigrant). Thus, a typical classroom dialogue about visiting a tourist site, such as the Eiffel Tower, is taken as an opportunity to examine how the tower is perceived by different people according to their backgrounds and experiences. In these classrooms, students are alerted to the risk of stereotyping and are invited to suspend judgment and place value on understanding other points of view. Intercultural attitudes become more accepting and flexible when students have multiple chances to compare sources and evaluate competing viewpoints originating with different groups, either within a culture or cross-culturally (Swaffar, Arens 2005).

Assessment

The challenge

How do we know if our students are learning? The proposed framework where language B is conceptualized as a constellation of language uses within a specific cultural context also includes an integrated view of student assessment.

Recommendations

Teachers who organize their instruction around the core principles outlined in this chapter can employ them not only to establish learning objectives but also to assess the degree to which their instructional approaches can be optimized to reach high levels of language mastery and intercultural sensitivity. In other words, teachers can ask themselves: Are activities structured so that the focus is on the contexts and grammatical structures that are essential to communicate about a specific content and to engage with a meaningful question? Can I revise this project or that assignment so that it serves as an opportunity for students to reflect about their own assumptions about cultural perspectives or communicative conventions? Am I carefully assessing students' progress in their capacity to adapt their language use and interpretation to various contexts? Am I designing assignments or structuring classroom discussions in ways that will enable heritage speakers to contribute their expertise in ways that others can respect and admire? Assessment and instruction are seen as mutually informative processes in a continuous circle, where assessment reveals students' strengths and weaknesses which, in turn, inform instruction. Teachers can refer to the ACTFL Integrated Performance Assessment (IPA) (Glissan et al 2003), a cluster assessment featuring three tasks, each of which reflects one of the three modes of communication—interpersonal, interpretive and presentational—as outlined in the *ACTFL Performance Guidelines for K–12 Learners* (1998) and the *Standards for Foreign Language Learning in the 21st Century* (National Standards in Foreign Language Education Project 1999).

Reframing a known (heritage) language

The challenge

If reflective language comparisons enrich learners' world views, they affect students' identity and perception of themselves, their home languages and cultures in no smaller measure. While this is crucial for all students, it takes a particular twist for students who are speakers of non-standard language varieties (non-standard Spanish, African American vernaculars). In particular, "heritage speakers", that is, those who speak a minority language as a result of their immigration histories, are particularly vulnerable when learning their home/native/first language as a foreign language in formal classroom settings.

In the United States, many of these students will have spent their lives in previous classrooms labelled as "English language learners", classified as not being able to speak English proficiently enough. If they decide

to study their home language formally for the first time in a language B class (a pattern that is not rare in the United States), they might be at risk of facing negative attitudes yet again. This time, however, those pervasive attitudes are towards their own first/home language. Some students are seen as having limited proficiency in more academically demanding contexts; others are seen as employing a language variety that is different from the one being taught. The unjustified negative attitudes towards non-standard language forms are easily perceived and often internalized by speakers, even at young ages. Consequently, these attitudes need to be urgently dismantled and replaced by more educated understandings of languages and language differences.

Recommendations

To avoid such negative attitudes, teachers can polish their practice in important ways. They can acknowledge students' strengths and scaffold their learning strategically. Activities that enable these students to share their expertise, help non-native speakers interpret situations and offer cultural background, including informal forms of communication (for example, unpacking a scene in a film, providing information about local terms used in a text, modelling pronunciation) are key.

Essential to teachers' success in nurturing heritage learners' communicative fluency is their willingness to revisit their own conception of the languages they teach. Heritage language speakers may produce a language that teachers perceive as "flawed" because it is different from the standard monolingual variety in their syllabus. Students may also exhibit "receptive proficiencies" in their heritage language but not produce such proficiencies in their heritage language, orally or in writing (Valdés 2005). In both cases, students are vulnerable to teachers' erroneous perceptions of their language variety or language proficiency as "defective". Teachers, and students, need to understand that there is nothing flawed with the students' language varieties or exclusive oral proficiencies. Language is learned informally by experiencing it in specific social situations. As Valdés (2001, 2005) clearly explains, language features perceived as "flaws" might not be "errors" or "incomplete acquisition", but instead embody a fully acquired communicative system that works well in its context of origin. For example, a variety of Spanish that emerges from the contact of Spanish and English speakers in California includes some simplified structures, borrowed words and influences between languages. This variety of the language differs from the standard monolingual variety being taught in language B classes but it is not "flawed". Rather, it is socially less prestigious in some communicative contexts but crucial for social adaptation in other contexts. In fact, employing a high academic register among peers in the streets of Los Angeles would prove as dissonant as employing emerging forms of informal Spanish in a formal school talk. As Valdés claims:

> What [these students] must learn is which features of [their own language variety] correspond to the features of the accepted monolingual varieties of the language and which features do not … Instruction must be based on an understanding of the acquisition of additional registers by monolingual speakers who have not had access to contexts in which these particular registers are used.
>
> (Valdés 2005: 418)

In general, heritage language speakers have acquired an informal register of the language by learning it casually at home, and are unlikely to have learned formal versions of their language at school (Valdés 2005: 431). Effective teachers design learning experiences that scaffold these students to learn which language forms (formal or informal) are more effective in different communicative situations. Effective teachers offer ample opportunities for students to examine the language/context/purpose fit, offering informative feedback along the way. As these students learn more academic forms of language, their colloquial language skills need to be framed not as incorrect versus correct, but instead as code-switching options: some forms are more appropriate for certain contexts. Indeed, opportunities to bring their colloquial forms into the classroom can benefit not only heritage speakers but all students in the class. For instance, students can be asked to write and act out a play that enacts a conversation among Spanish- or French-speaking youth. Subsequently, they write a second play that reports the same events in the context of a news programme. Alternatively, they can create a political cartoon dialogue that is then transformed into a formal TV debate.

Occasionally, teachers will be able to draw on students' understanding of academic language register in language A and invite students to make cross-language comparisons.

The same ingredients of close analysis of rich texts through supported classroom interactions recommended previously can enable these students to learn to use their language in new contexts appropriately. Of the essence is making explicit connections between registers and contexts: those used for communicating at home, with friends, on a music radio station will differ from an academic paper, which is expected to use other forms that achieve the preciseness, diversity of advanced vocabulary and language autonomy expected of the language of school.

A word on individual differences in the language B classroom

The challenge

Finally, we cannot overemphasize the need to include, in our reflections about language B instruction, attending to the individual characteristics of each of our students. On the one hand, our students bring into the classroom different learning styles. Each student has a different way to process information—visual, auditory, kinesthetic—so teachers need to ensure that they present their materials and incorporate activities according to these differences. Clear visual aids, engaging audios and activities such as role playing, where students enact dialogues, are valued pedagogical resources. On the other hand, we also need to reflect on the fact that our classrooms are becoming more ethnically diverse than ever. Students from very different cultural and linguistic backgrounds are taking Spanish classes, for example, and teachers need to be aware of the different cultural backgrounds, and even linguistic transferences, that might occur in the process of learning language B. As mentioned in the previous paragraphs, valuing minority students' language and home cultures is a central component in today's classrooms.

Recommendations

A first step for teachers is to reflect on their own feelings towards each one of their students, and be aware of any concerns that can hinder the teaching–learning process. They can, for example, ask themselves questions such as: What do I know about my students' community and culture? Do I know their family history? What do I know about their home values? Do I feel comfortable working with students from this community? Why? (Parra 2009). As any other teacher, we need to remember that our attitudes towards our students have a substantial impact on students' self-esteem and motivation. If teachers embrace students' individual characteristics and understand students' backgrounds as highly valuable knowledge (as opposed to deficient knowledge), students will feel more inclined to connect with the language and fulfill high expectations.

Conclusion

An instruction centred on core principles, such as the ones proposed in this chapter, invites teachers to move beyond presenting isolated grammatical forms and disconnected and decontextualized activities. It calls on teachers not only to invite students to participate in the discussion of motivating topics and significant questions, but also to teach vocabulary and grammatical **choices in the context of particular purposes for using language** selected for their relevance to the overarching theme being discussed; to reveal relevant cultural conventions; to expose students to key knowledge sources; and to reflect on multiple positions triggered by different cultural beliefs, social positions and the pragmatic goals of speakers. By focusing on these ideas as pillars of language B instruction, over time teachers can maximize the effect of their instruction, as students will be developing well-grounded communicative habits and skills as opposed to learning easy-to-forget isolated drills and expressions. In this way, a curriculum centred on core principles deepens our sense of the IB aims and foreign language standards described earlier in this chapter by articulating dimensions of language learning that are key to consider in an integrated communicative approach that goes beyond parallel inventories of skills.

To conclude, in this chapter we have argued that quality teaching of language B for all requires an integrated approach to instruction. We have claimed that to maximize students' enduring and effective understanding of another language, high-quality instruction focuses on **context-relevant, culturally informed, reflective language uses** to achieve **language fluency** and **intercultural sensitivity**. In effective classrooms, all learning experiences are designed to help students understand that language is shaped by context; that language reveals cultural conventions and cultural legacies; and that languages enable us to reflect about ourselves and others. In so doing, effective language B teachers are able to reach a productive balance between engaging students in topics that are relevant and ensuring that such engagement also yields linguistic understanding.

In a world of increasing global interconnectedness, language B teachers are strategically positioned to prepare students to succeed in their further education, at work and in civic life. An approach that focuses teachers' and students' attention on what matters most to learn about a language other than one's own, and does so informed by approaches based on research, provides an important opportunity for IB teachers to nurture a new generation of young citizens who embody core qualities of mind embodied in the IB learner profile aspirations and participate effectively in today's world (in their classrooms and communities) as they prepare for tomorrow's world.

References

American Council on the Teaching of Foreign Languages (ACTFL). 1998. *ACTFL Performance Guidelines for K–12 Learners*. Alexandria, VA, USA. American Council on the Teaching of Foreign Languages.

Bennett, M. 1998. *Basic Concepts in Intercultural Communication. Selected Readings*. Boston MA, USA. Intercultural Press.

Bialystok, E and Feng, X. 2009. "Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults". *Brain and Language*. Vol 109, issues 2–3. Pp 93–100.

Common European Framework of Reference for Languages: Learning, Teaching, Assessment. 1996. Retrieved from http://www.coe.int/t/DG4/Portfolio/?M=/main_pages/levels.html.

García, O. 2009. *Bilingual Education in the 21st Century*: *A Global Perspective*. Malden, MA, USA. Oxford, UK. Wiley Blackwell.

Glissan, EW, (ed), Adai-Hauck, B, Koda, K, Sandrock, SP and Swender, E. 2003. *ACTFL Integrated Performance Assessment*. New York, USA. American Council on the Teaching of Foreign Languages.

Hammer, MR, Bennett, MJ and Wiseman, R. 2003. "Measuring intercultural sensitivity: The Intercultural Development Inventory". In RM Paige, (ed). Special issue on the Intercultural Development. *International Journal of Intercultural Relations*, Vol 27, number 4. Pp 421–443.

Katz, S and Blyth, C. 2007. *Teaching French Grammar in Context: Theory and Practice*. New Haven, Connecticut, USA. Yale University Press.

Modern Language Association (MLA). 2007. "Foreign languages and higher education: New structures for a changed world". New York, USA. MLA.

Pang, TT. 2002. "Textual analysis and contextual awareness building: A comparison of two approaches to teaching genre". In A Johns, (ed.) *Genre in the Classroom: Multiple Perspectives*. Mahwah, New Jersey, USA. Lawrence Erlbaum Associates.

Parra, ML. 2009. "Parent-teacher connection. Teacher interview results". Presentation at East Palo Alto Academy. Professional Development Workshop for teachers. East Palo Alto, California, USA.

Potowski, K, Berne, J, Clark, A and Hammerand, A. 2008. S*panish for K–8 Heritage Speakers: A Standards-Based Curriculum Project*. Hispania. Vol 91, number 1. Pp 25–41.

National Standards in Foreign Language Education Project. 1999. *Standards for Foreign Language Learning in the 21st Century*. National Standards in Foreign Language Education Project.

Style, E. 1996. "Curriculum as window and mirror". *Social Science Record*. Pp 35–42.

Swaffar, J and Arens K. 2005. "Remapping the foreign language curriculum: An approach through multiple literacies". New York, USA. Modern Language Association of America.

Taylor, C and Lafayette, R. 2010. "Academic achievement through FLES: A case for Promoting Greater Access to Foreign Language Study among young learners". *Modern Language Journal*. Vol 94, number 1. Pp 22–42.

Valdés, G. 2001. "Heritage languages students: Profiles and possibilities". In JK Peyton, DA Ranard and S McGinnis (eds). *Heritage Languages in America: Preserving a National Resource*. Washington, DC, USA. Center for Applied Linguistics/Delta Systems.

Valdés, G. 2005. "Bilingualism, heritage language learners, and SLA research: Opportunities lost or seized?" *Modern Language Journal*. Vol 89. Pp 410–426.

Appendix 1: The five Cs of foreign language education

Communication is at the heart of second language study, whether the communication takes place face-to-face, in writing, or across centuries through the reading of literature.

Through the study of other languages, students gain a knowledge and understanding of the ***cultures*** that use that language and, in fact, cannot truly master the language until they have also mastered the cultural contexts in which the language occurs.

Learning languages provides ***connections*** to additional bodies of knowledge that may be unavailable to the monolingual English speaker.

Through ***comparisons*** and contrasts between the first language and the new or second language being studied, students develop insights into the nature of languages and the concept of culture, and realize that there are multiple ways of viewing the world.

Together, these elements enable the student of languages to participate in multilingual ***communities*** at home and around the world in a variety of contexts and in culturally appropriate ways.

(National Standards in Foreign Language Education 1999)

Appendix 2: Intercultural sensitivity and intercultural competences

From Bennett, 1998; Hammer, Bennett, Wiseman 2003. Retrieved from http://www.wpi.edu/Images/CMS/IGSD/IGSD_retreat_May07_DMIS.pdf.

- **Intercultural sensitivity:** The ability to discriminate and experience relevant cultural differences.
- **Intercultural competence:** The ability to think and act in interculturally appropriate ways (Hammer, Bennett and Wiseman 2003).

A developmental model of intercultural sensitivity (Bennett 1998)

Ethnocentric stages

I. Denial of difference

"All big cities are the same—too many cars, McDonalds".

"Since we all speak the same language, there's no problem."

II. Defense against difference

"When you go to other cultures, it makes you realize how much better the US is". (Superiority)

"I wish I could give up my own cultural background and really be one of these people". (Reversal)

III. Minimization of difference

"Customs differ, of course, but when you really get to know them they're pretty much like us, so I can just be myself".

Ethnorelative stages

IV. Acceptance of difference

"Sometimes it's confusing, knowing that values are different in various cultures and wanting to be respectful, but still wanting to maintain my core values".

V. Adaptation to difference

"I greet people from my culture and people from my host culture somewhat differently to account for cultural differences in the way respect is communicated".

VI. Integration of difference

"Whatever the situation, I can usually look at it from a variety of cultural points of view".

Appendix 3

Core language domains	Core language domains applied	Relevant NSFLE Standards
Context Context-relevant language use	**How do I want to communicate what to whom?** • To whom am I speaking? • What do I want to communicate and why? • How am I communicating? **Understanding register, genres and modality** Provide reading, listening, speaking and writing opportunities for students to understand: • how different registers of the language are expected when addressing different audiences (for example, informal/colloquial versus formal/academic) • how different genres (narrative, description, persuasion) require different linguistic forms • how different modalities (oral versus written) rely on different language features for successful communication • how input and output opportunities interact with different audiences (formal versus informal; familiar versus unfamiliar), communicate different messages (describing, narrating, persuading; different disciplinary genres) and engage in different modalities (oral versus written; digital media); this will serve to promote mastery of context-specific language forms. **Possible activities** Students may produce language to communicate the same message for different audiences (for example, they could orally describe an incident using playground language directed to a peer or use academic/classroom language addressed to a teacher/principal; they could write a persuasive essay to a peer or to the school principal). Students may analyse the linguistic features characteristic of different subgenres (for example, they could analyse a written movie retelling and compare it to an authentic movie review or an authentic opinion article). **Linking content and language** Provide the linguistic structures needed for selected registers, genres and topics. For example: for description, use adjectives and the verbs "*ser*" and "*estar*"; for narrating, use temporal discourse connectors; for persuasive essays, use logical connectors and discourse markers.	**Communication** Standard 1.1: Students engage in conversations, provide and obtain information, express feelings and emotions, and exchange opinions. *(Interpersonal communication)* **Communication** Standard 1.2: Students understand and interpret written and spoken language on a variety of topics. *(Interpretative communication)* **Communication** Standard 1.3: Students present information, concepts, and ideas to an audience of listeners or readers on a variety of topics. *(Presentational communication)*

Core language domains	Core language domains applied	Relevant NSFLE Standards
Culture Culturally sensitive and cultivated language use	**How can I use language in culturally sensitive ways?** **Possible activities** Historical texts, current events, films, literature, artworks or videos can be used to provide reading, writing, speaking and listening opportunities in which students encounter linguistically/culturally specific beliefs, behaviours and ways of communicating (multiple language varieties can be represented). **Beliefs and behaviours** Students can engage with authentic texts, websites, videos, artworks from different contexts to learn about various beliefs related to family values, men–women relations, love, social expectations, and so on. Students may be invited to interview native speakers from the second language to ask them for anecdotes about miscommunication or "cultural shock" with English speakers. Historical and current activities typical of the language/culture can be learned and discussed in class, for example, *la tertulia*, bullfighting and so on. How can I share the common cultural references, history, literature, art and accumulated knowledge of the native speakers for a more meaningful use of language? Understanding the history, art and accumulated knowledge associated with the language **Possible activities** Students may study literary texts, historical speeches, films, songs or journalistic articles in the new language. The historical periods, artistic and literary traditions convey a common ground of cultural knowledge to engage in meaningful communicative exchanges with native speakers of the new language. Additionally, such materials may represent universal themes such as identity, social struggles, human emotions, conflicts or development—to mention just a few—that will lead students to reflect about deep issues that concern all individuals across cultures/languages.	**Cultures** Standard 2.1: Students demonstrate an understanding of the relationship between the practices and perspectives of the culture studied. **Cultures** Standard 2.2: Students demonstrate an understanding of the relationship between the products and perspectives of the culture studied. **Connections** Standard 3.1: Students reinforce and further their knowledge of other disciplines through the second language. **Connections** Standard 3.2: Students acquire information and recognize the distinctive viewpoints that are only available through the foreign language and its cultures.

Core language domains	Core language domains applied	Relevant NSFLE Standards
Reflection Reflective language use	**How do speakers of different languages/members of different cultures interpret their own and others' beliefs, behaviours, ways of communicating?** **Reflecting on the interpretation of situated language/ cultural practices across societies** Learning about distinct forms of communication, understanding contrasting beliefs and behaviours should lead to guided reflections about the conventional nature and/or situated relevance of specific practices. Politeness is a highly relevant area for this reflection. **Comparisons across languages and cultures** Ways of communicating can be compared. For instance, when analysing turn-taking, students may come to see that overlapping in conversation is interpreted as a rude interruption in most English-speaking societies, and as a sign of listener's engagement in many Spanish-speaking contexts. **Alternative perspectives** Analysing news that is presented differently in distinct newspapers around the world can help students understand the situated perspective of speakers of different languages.	**Comparisons** Standard 4.1: Students demonstrate understanding of the nature of language through comparisons of the language studied and their own. **Comparisons** Standard 4.2: Students demonstrate understanding of the concept of culture through comparisons of the cultures studied and their own.
Fluency Fluent, context-relevant, culturally appropriate, cultivated, reflective language use	Fluency in language use entails understanding the centrality of authentic practice inside and outside the language classroom. Language practice is at the core of language learning. Putting together our knowledge on context, culture and reflective use of language when communicating—through face-to-face interactions or through written texts—with different members of the language B communities.	**Communities** Standard 5.1: Students use the language both within and beyond the school setting. **Communities** Standard 5.2: Students show evidence of becoming lifelong learners by using the language for personal enjoyment and enrichment.

Appendix 4: A unit on ecotourism

Overview

The unit on ecotourism outlined below illustrates how language B teachers can design instruction based on the core principles of context, culture and fluency while exploring a topic of genuine interest to students and society. In this unit, the core principles outlined in this chapter inform the definition of the unit topic, learning goals, learning experiences and assessment criteria. Central to the unit is the creation of an information campaign in support of tourism that is respectful of cultural heritage and the natural environment in the Andean Machu Picchu ruins. In a core simulation, students are called upon by an editorial company to design two booklets or brochures introducing ecotourism in the Machu Picchu ruins in Peru to two different audiences: a group of students of their own age and a group of experts.

Unit guiding question

How can I be a respectful tourist and how can I help others become respectful tourists?

Core language domains

We have a responsibility when visiting other places to be respectful of their cultural practices, beliefs and heritage and to protect the environment.

In creating informative and persuasive texts, the target audience must be considered in determining what language will be effective.

Unit topic

Visiting Machu Picchu as respectful tourists: a persuasive campaign.

Understanding goals

Culture

Students will

- understand the ecosystem surrounding the ruins and the risks presented by commercial tourism
- understand the significance of the Machu Picchu ruins as part of the broader historical legacy of the Inca civilization.

Language

Students will:

- learn to interpret different texts (newspaper and magazine articles)
- learn to use different registers, descriptive and persuasive language and grammar to encourage responsible tourism and advertise the sites targeting two different audiences (students and experts).

Sample activities

- Students read/listen to materials (and view art) to become acquainted with Machu Picchu in different ways. These texts and materials represent different genres, registers and modalities. Suggested texts include newspapers or magazine articles on ecotourism, opinion articles, texts about culture and history in Peru and Machu Picchu. (**Context/culture**)
- Through close reading of texts, students compare and contrast genres and registers. Students analyse each type of text examining, for example, specific phrases, use of examples, technical terms. What

language is characteristic of each genre? How can we differentiate between formal and informal language? Is the author describing, narrating or trying to persuade us? How do we know? Special attention is paid to texts that differ by audience (tourist information advertisements for youth as opposed to adults) or by genre (a personal anecdote about a trip rather than a tourist information advertisement for young people). (**Context/reflection**)

- Working in groups, students prepare for the production of their brochure. Their discussion is guided by questions such as: Why it is important to talk about ecotourism and ancient cultures and archeological sites? What practices are in place to protect Machu Picchu from excessive tourism? How may Machu Picchu be interesting to young people? What may be interesting to experts in historical preservation? What information would be relevant for students and international organizations to know? (**Context/culture/reflection**)
- Students integrate their linguistic and cultural knowledge into their final project: What is the structure of their brochures? What specific cultural content are they going to include for students and for members of international organizations? What specific language or expressions are they choosing as a reflection of culture and cultural understanding? (**Fluency/context/culture/reflection**)
- In groups, students present their findings and brochure. Special attention is paid to the use of expressions such as: "*aconsejar que*", "*esperar que*", "*insistir que*", "*pedir que*", "*permitir que*", "*preferir que*", "*prohibir que*", "*querer que*", "*recomendar que*", "*sugerir que*", "*es importante/(im)possible/(in)admissible/necesario/obligatorio*"; "*referible que*". (**Fluency/context/culture/reflection**)

Appendix 5: Instruction focused on core domains versus a traditional approach in language B

The following table briefly summarizes a few key differences in the roles teachers, students and classroom activities play in a traditional approach versus the proposed integrated approach designed around the four core domains proposed here.

Traditional approach	Core domains
Student: The student is a **passive receiver** and repeater of information; learner of abstract rules, mostly via explicit grammatical lessons and little actual use; language B is learned as an abstract system of rules instead of as a system for authentic and relevant communication.	**Student:** The student is an **active participant** in learning the language B. The student builds a new linguistic system using his or her first language, previous knowledge and creativity.
Classroom: In general, little attention is paid to meaning; activities are often based on decontextualized exercises that foster memorization and mechanical practice.	**Classroom:** The classroom becomes a collaborative space where students learn how to communicate different messages effectively to various audiences about different topics in the language B.
Teacher: The teacher is the presenter and main resource of knowledge.	**Teacher:** The teacher is a source of input; a guide in the process of collaborative learning with students; a guide in intercultural reflections.
Foreign language learning: Learning of grammatical rules and vocabulary is at the centre of the instruction. They are often disconnected from content, and from authentic communication.	**Foreign language learning:** Learning new ways to communicate with others as a process of socialization within another culture.
Objectives: These are usually framed on the basis of the grammatical knowledge to be learned, without particular attention given to communicative contexts and authentic/relevant/engaging topics.	**Objectives:** These are framed around big ideas that underlie an in-depth understanding of language and culture.
Content and language: Curricular selections of content tend to be made independently of the curricular selections of grammar and vocabulary.	**Content standards are aligned with language standards** in such a way that the grammatical and vocabulary selections are the key language forms necessary to the particular content, register and genres to be practised in class.

Teaching for disciplinary understanding in science

By Aaron Rogat with Veronica Boix Mansilla

Why should students understand science?

Scientific discoveries have the potential to provide solutions to some of the world's most pressing problems and, at the same time, can lead to some of society's most daunting threats. Important technologies from digital cameras to the MRI and X-ray machines or new antibiotics used by millions of people worldwide stem from scientific inquiry. In making choices, whether in the doctor's office, or as advocates for policy changes, we benefit from, and influence the fate of, scientific advances. It is critical that adults graduating from secondary school understand both science content and science process.

The IB Middle Years Programme (MYP) and Diploma Programme (DP) curriculums show appreciation for connections between science and society and suggest that students should understand how science impacts their lives in personal, social and civic ways. The IB curriculums prepare students to relate the content of the classroom and laboratory to the realities of life as they develop critical-thinking and problem-solving skills. IB students learn to apply scientific knowledge and the scientific approach to problem-solving—that is, the ability to formulate hypotheses, design and carry out experiments to test them, and evaluate results.

Understanding the purposes and multiple applications that drive scientific inquiry, and encouraging students to transfer what they learn in class to novel contexts in the world, are worthy goals. Yet, in order to make informed arguments and participate in debates on issues relating to science and society, students need a deep understanding of science content. How are teachers to decide which topics or concepts in science matter most for students to learn? Across the vast territory of scientific knowledge available to us today **it is the big ideas or important concepts in science** (discussed below) **that have the most explanatory power** and that will be the most beneficial for students to learn and master.

What is science?

Science explains the natural world

Quality teaching in science begins with clarity about what science is and the purpose it pursues as a form of knowledge production. While many of the domains and sub-disciplines of science pursue different questions and use quite different methods to find answers to their questions, there is one central purpose common among all the sciences that distinguish them from other academic disciplines: the search for theories that help to explain or predict natural phenomena (American Association for the Advancement of Science (AAAS) 1989). A natural phenomenon may be something that can be observed by people without special equipment or sophisticated experimentation (such as the phases of the moon, objects that float while others sink, or why the offspring of an animal looks similar to its parents). At other times, special equipment or specially designed investigations are needed to observe the natural event. The point is that the phenomena scientists attempt to account for occur in the natural world, not the human-made world. (The latter is the domain of engineering or a technological field such as computer science)[3]. Regardless of the domain or sub-discipline, **the use of data**

[3]Sometimes people refer to the "hard sciences", while the social sciences are those that include sub-disciplines such as sociology and anthropology. While investigators in those disciplines also search for explanations of observed events and use evidence to construct or revise theories and models, it can be argued that the phenomena they study are grounded in the human or social world, rather than the natural world.

and evidence is central and given special priority when constructing and revising models and theories developed to explain or predict natural phenomena (National Research Council (NRC) 2007).

Scientific knowledge is provisional

A second fundamental feature of science is the idea that scientists revise their thinking based upon evidence. Students often enter our classrooms with the naive conception that knowledge in science is static and unchanging. Lessons should help students understand that scientists are continually on the search for more powerful theories and models that can account for, and predict, more phenomena (NRC 2007). For example, a lesson on cell division or ecological interdependence may begin by asking students to create graphic representations characterizing these phenomena. Through further analysis of information, data, and with deliberation, students can be invited to edit and improve their models. In fact, scientists engage in precisely this kind of argumentation and debate, analysing each other's evidence and theories in order to identify the most satisfactory theories and models. While the process is not linear—as is often portrayed in science courses—scientists do engage in iterative cycles of proposing a hypothesis to account for a particular phenomenon and collecting data and evidence to support or refute their hypothesis (NRC 2007). Scientists also continually develop and apply more sophisticated investigatory methods (for example, more powerful microscopes or telescopes) and analytical tools (for example, statistical tools) in order to collect and analyse more accurate and reliable evidence. Given these core features of the practice of science, students need to understand **scientific knowledge** (that is, disciplinary knowledge); **the process by which science is generated** (that is, disciplinary methods); **the purposes that motivate scientific inquiry**—to explain and predict natural phenomena (disciplinary purpose); and **the ways in which scientific knowledge is communicated**—as evidence-based, yet provisional, explanations of the natural world.

Towards a curriculum of science practice and big ideas

Engaging students in science practices

How can teachers help students understand the nature of scientific inquiry as described above? In order to support understanding of the ideas and process of science, students must be given opportunities to participate in constructing and revising explanations or models for particular natural phenomena, which also means they must engage in collecting, analysing, and interpreting data, as well as presenting and debating evidence (NRC 2007). It is through doing and practising these domain-specific tasks that students will gain a better appreciation of their role in science. At the same time, by engaging in these practices of science, students can gain understanding of the scientific body of knowledge that scientists have developed over the centuries. Engaging students in the process of science can help them to understand the key scientific principles, theories and models targeted in curriculum standards.

Accordingly, it is important that all curriculum units include opportunities for students to collect evidence, construct explanations or arguments (often in groups emulating the scientific community), and share those explanations or arguments in class discussions where they can publicly debate and critique different ideas. Students should also be given opportunities to share their ideas by presenting models that account for particular natural phenomena; such models may be causal models that can be represented with drawings (for example, arrow diagrams or simulations) or other physical representations, such as stream tables (in earth science) or ball-and-stick models (in chemistry). Units should include opportunities for students to reflect on the scientific significance of their explorations—why the problems they study matter and how their insights might be applied.

Focus on big ideas in science

As teachers of science, we are also faced with another key challenge—how can we best support students' understanding of science content? Research on how experts in science think, reason and problem-solve

suggests a few key principles that have implications for lesson design, classroom instruction and assessment. Experts organize their deep conceptual knowledge around big ideas or core ideas within the discipline (NRC 2000). Core ideas or big ideas can be used to explain or predict a vast range of natural phenomena—these often are the powerful theories, models, principles or laws that scientists use. Experts also know when, and in what circumstances, to apply these ideas. For example, key principles, such as the conservation of energy or Newton's laws of force and motion, are the organizing principles for many expert physicists. Physicists not only know the relationships between the variables addressed in these principles, but also in what situations to apply them (Chi, Feltovich and Glaser 1981). This research suggests that teachers focus on these big ideas and identify not only what they are but how and when to apply them.

Core and big ideas are explanatory frameworks to make sense of the world. The National Research Council's (NRC) *A Framework for K-12 Science Education: Practice, Cross-cutting Ideas, and Core Ideas* (2012)[4] has identified many of these core ideas (see "Appendix 3"). This document identifies the core ideas (such as evolution in the life sciences and the structure and properties of matter in the physical sciences). Core ideas of this kind are not just concepts that stand in isolation. Rather they imply a network of concepts that work collectively as an explanatory framework. For instance, in the life sciences, a core idea is that "biological evolution explains unity and diversity among species" (NRC 2012). Thus conceived, "evolution" implies a system of thought that includes a number of significant concepts, some might call them big ideas, such as genetic variation among species within a population, and adaptation and natural selection as well as the relationship between these. As a whole, this system of powerful concepts and relationships forms the theory of evolution used to explain species differentiation, extinction and other phenomena.

Core scientific ideas such as evolution operate as explanatory frameworks to help us make sense of the natural world. It follows that understanding core ideas in science, such as evolution or the structure and properties of matter, demands more than remembering definitions. Students demonstrate an understanding of such core ideas in science when they can deploy the system of related concepts and facts involved appropriately to explain a novel phenomenon or observation.[4]

The IB curriculums identify a variety of powerful ideas and concepts that can be used to account for multiple facts. For example, DP biology students are invited to learn about the relationship between structure and function, universality and diversity in nature. They explore systems and their equilibrium. In MYP sciences, learning might be organized around the big idea that substances can undergo physical and chemical changes that affect their properties. These changes occur in both living and non-living systems and are influenced by the same factors.

What is the role of facts in a core ideas-focused curriculum?

Instruction focused on core ideas does not suggest that facts are unimportant to understanding science. Indeed, experts have a deep understanding of facts, but those facts are linked to core ideas and other ideas and facts in a coherent way so that they can be easily retrieved and applied when needed. Facts and information add specificity and robustness to our scientific understanding. However, research in science education is clear that facts should not be the principal focus of classroom instruction and assessment. Instead, the significant concepts, ideally the core ideas (those ideas with the most explanatory power), should be the focus of instruction.

What if a unit cannot be easily linked to a core scientific idea?

When teachers cannot find a good match between the mandated curriculum or standards and core ideas or big ideas in science, they should not revert to covering isolated facts. Rather, they should focus instruction on important **concepts** that can be related to the curriculum most directly. Like core ideas and big ideas, concepts cannot be easily memorized or captured by fill-in-the blank or definitional assessment items.

[4]In the United States, the NRC approach to science content described here will inform the new national standards to be available in 2012. In previous years the *National Science Education Standards* (NRC 1996) and the *Benchmarks for Science Literacy* identified significant concepts from grades K–12 (AAAS 1993, 2001, 2007).

Concepts represent more abstract ideas, often forming generalizations or principles that can be applied to explain or predict a range of phenomena. For example, memorizing the number of human chromosomes is a fact and has very limited applicability or explanatory power when thinking about the genetics of other organisms. However, understanding that genes influence the function and appearance of an organism and are found on chromosomes that are passed on from generation to generation is a concept that has much more explanatory power and can be applied to all organisms. Concepts rarely include a specific number or specific terms. Facts have much more limited explanatory power and often can only be applied to a few limited situations.[5]

How do students develop scientific competence?

Current researchers in science education suggest that once core ideas in science have been identified in a curriculum or syllabus, it is incumbent upon the developers of the curriculum or teachers using the curriculum to provide students with opportunities to revisit the ideas in subsequent units or years, so that they can develop more sophisticated understanding of such ideas and more proficiency in how to use those ideas (NRC 2007). Students need several encounters to develop and master ideas that are abstract or are not intuitive, such as evolution or the atomic molecular theory.

Learning core ideas occurs progressively over time and involves multiple experiences: Biology—an example

Consider, for example, the concepts of natural selection and adaptation as part of students' understanding of evolution. Understanding natural selection and adaptation involves understanding how environments influence populations of organisms. When an environment changes, some resource supplies change, thereby exerting selective pressures for the survival and reproduction of some organisms over others. Surviving populations are those most fit for the new resource availability and are seen as adaptive. Complex ideas of natural selection and adaptation are constructed by students over time with increasing levels of complexity. An appropriate teaching design parallels students' capacity to understand this complex idea, providing good foundations early in their education or in a course and inviting students to add nuance and complexity to their fundamental understanding over time. The goal is to ensure that students can build a strong and flexible understanding of the idea in developmentally appropriate ways.

Students in grades K–2 may observe natural habitats and learn that living things can only survive in environments in which their needs are met. These students may also learn that there are multiple environments on the planet able to support different types of living things. Students in grades 3–5 may learn about how a change in an organism's habitat may be beneficial or harmful for its survival. In years 1–3 of the MYP, a student may revisit this idea, examining the genetic variation that exists within a given species, how traits may give some organisms advantage over others, and how individuals who survive to adulthood are more likely to reproduce and have offspring who carry adaptive traits as well. Finally, in MYP years 4 and 5, and as they move into DP biology, students may understand that natural selection results in a broad diversity of organisms that are anatomically, behaviourally and physiologically well suited to survive and reproduce in a specific environment. They may understand the relationship between rate of survival and reproduction of organisms with a given trait in a population and the proportion of individuals in future generations holding that trait. They may explore biotic and abiotic environmental changes, explain causes of extinction and understand the dramatic role of Darwin's theory of evolution to make sense of a massive array of observations and facts (NRC 2000).

By designing purposefully spiralled science curriculums in which students revisit core foundational ideas with increasing levels of complexity and specificity, today's science educators can enhance the likelihood

[5]A useful reference for this approach can be found in a paper by Cartier and Pellathy (2009).

that students will build a deep foundational understanding of core ideas in science. The IB publication *Science across the IB continuum* (July 2011) provides guidance for schools developing tighter articulation between their MYP and DP science curriculums.[6]

Misconceptions—a frequent challenge

Given available research of student learning progressions in science, it is rather unreasonable to believe that after one unit or even one year, students will master the targeted core ideas in science that we have set for them. This is particularly true when misconceptions are present in students' thinking. Some misconceptions can cause stumbling blocks to developing more sophisticated understanding in school and can persist well into adulthood. In fact, researchers have found some teachers hold many of the same misconceptions that their students have. For example, consider the notion discussed above that natural selection favours variations among individuals within a population, and that over time the population changes. This understanding can be contrasted with the naive conception that changes to an individual's physical characteristics within its lifetime can always be passed on to future progeny. It takes time and the incorporation of other ideas into a student's mental framework through careful instruction to develop the accurate understanding of how variation is a component of evolution acting in combination with natural selection.

The physical sciences offer another example to consider; it takes time to distinguish entities at the microscopic level (for example, atoms and molecules) and internalize the principle that all matter is conserved, even during physical and chemical transformations. Students often give microscopic entities macroscopic properties (for example, believing there are "hard" molecules and "soft" molecules). They often think that matter completely vanishes from existence when transformed into a gaseous state. Students need time and careful instruction to master the understanding and use of these ideas. The same is true of the science practices that we want students to master, such as constructing explanations or analysing data. It takes time for students to develop these process skills.

Students come to school, or begin the study of any particular content, with plenty of pre-existing ideas. Sometimes they are misconceptions or naive thinking informed by their perceptual experiences with the natural world and students can be completely unaware of the microscopic physical world or the invisible forces that they encounter every day. Teachers must identify these initial ideas because they are the learner's point of departure and will shape what is eventually learned. Some prior conceptions can be taken advantage of, even if they are incomplete or partially inaccurate scientifically. These initial ideas can serve as leverage to developing more sophisticated understandings. For example, the particulate model of matter is an incomplete idea. This is the notion that matter is made up of very tiny particles that move around (atoms in this model are not necessarily distinguished from molecules—so it is an incomplete idea). Yet, this intermediate understanding may be leverage to understanding the more sophisticated idea that matter is made up of tiny particles, which themselves may be atoms or combinations of atoms. Thus, a particle model, although incomplete, may be a stepping stone to the targeted level of understanding about the structure and behaviour of matter. Often, teachers are able to make productive use of students' particle theory of matter by eliciting it first and then enriching and transforming it.

Learning progressively over time and the spiral curriculum—a productive approach

Revisiting core academic ideas and practices is not a new idea in education. However, recently researchers have been recommending that developers of standards, curriculum and assessment develop descriptions of how students' thinking of core ideas in science change and become more sophisticated over time (Smith et al 2006; Corcoran, Mosher and Rogat 2009). Ideally, these descriptions are based on research, or empirical evidence, of how students learn the big ideas. When such research-based descriptions of student thinking are not available (NRC 2007; Corcoran, Mosher and Rogat 2009) it is appropriate to create

[6]The IB science continuum forum on the online curriculum centre (OCC) (http://occ.ibo.org) provides teachers with more specific resources and discussions.

hypothesized progressions. The NRC framework, along with the American Association for the Advancement of Science (AAAS) atlas maps (2001), are essentially hypothesized progressions. Frameworks that outline a pathway for how students can move from their early ideas to the targeted level of understanding or ability serve as useful tools. These tools can support developers and users of curriculum to design or modify lessons so that they are more coherent and build on one another. Currently, much curriculum is highly modular and lacks coherence (NRC 2007) and students do not get a chance to build on their prior ways of thinking about the core idea.

All too often, units of instruction have one lesson to address a concept, and make the assumption that one activity will be sufficient to help students master a particular idea. While this approach might be effective in teaching isolated facts, it is considerably less so when aiming for core ideas and deep understanding of the networks of concepts that give them meaning. Effective science instruction pays close attention to what students learned before and where they need to go next. Students are then given multiple opportunities to revisit the core ideas and to re-examine their own thinking, not only across multiple years, but within a single unit. Thus, students' progression in learning can be considered across grades and within grades. The IB *Programme standards and practices* (2010) requires the MYP to develop and regularly review subject-specific vertical planning documents. For the sciences, this process should include specific attention to learning progressions.

Designing instruction: Preparing students to interpret the world like scientists

Quality instructional designs in science focus on core ideas and big ideas as well as processes of the kinds described above. They build on empirical or hypothetical depictions of how, over time, students develop an increasingly sophisticated understanding of core scientific ideas. Informed by such ideas and progressions in student learning, teachers and curriculum developers can devise learning experiences that are at once attractive for students and effective in helping them to work with the concepts to be learned. Such experiences are designed to help students move beyond powerful initial partial understandings, to confront early beliefs and misconceptions, to find novel connections or syntheses. Carefully crafted sequences of learning experiences and assignments allow students to revisit and deepen their understanding of core ideas. This does not suggest that lessons should be simply retaught, but rather that students are asked to apply their prior ideas in new contexts, explore new phenomena, and collect new evidence that will encourage them to rethink or extend their thinking of the core ideas in science. In MYP science, one of the objectives is that students are able to "apply scientific knowledge and understanding to solve problems set in familiar and unfamiliar situations" (International Baccalaureate 2010b: 5). Ongoing assessment enables teachers to monitor how students are progressing along the hypothesized pathways and inform the design of subsequent learning experiences.[7]

A close examination of successful science lessons reveals several common features.

- **Focus on core/big ideas.** The lessons identify for teachers the big ideas of focus in the lesson (this is most clear in the introductory materials to the unit). In the MYP, each lesson contributes to student understanding of the significant concept for the unit.
- **Clear sense of relevance.** The lessons attempt to use everyday phenomena that students might be aware of so the phenomena can promote a sense of relevance. In the MYP, the areas of interaction provide a context for the lessons, providing students with explicit connections to their own experience.

[7]A detailed description of a sample unit that illustrates quality instructional designs geared towards helping students interpret the world like scientists is provided in Appendix 1.

- **Making early ideas public.** The lessons often require students to make their initial and prior ideas public to teachers (or they recall important experiences or ideas from a previous lesson)—therefore, "key questions" are often posed at the beginning of each lesson to elicit these ideas from students. The MYP expectation is that instruction will be a process of genuine inquiry that may begin with activities that lead to authentic student questions.
- **Collect evidence and explain phenomena.** Many of the lessons engage students in first-hand phenomena to collect evidence that directly relates to the core idea and associated big ideas, or that allows them to explain the phenomena using multiple representations. These types of activities are essential to develop student abilities for the MYP objectives of scientific inquiry and communication in science.
- **Making sense of observations.** Most lessons require students to engage in a "think-and-write" task at the end, intended to support sense making (as such, these "think-and-write" tasks may ask students to connect evidence from the investigation to the conceptual models they are supposed to develop, and they may ask students to rephrase a concept in their own words, or ask students to apply the ideas learned from the unit to a new problem or context).
- **Attending to learning challenges and progressions.** Most lessons focus on core ideas and their associated big ideas, or significant concepts. The lessons also allow students to engage with multiple phenomena (and/or representations) directly related to the ideas, and confront naive conceptions elicited through strategically inserted questions and activities. In developing MYP units, attention should be given to ensure that lessons unfold in a coherent and deliberate order—one that focuses on significant concepts or ideas and develops the understanding with increasing levels of complexity. In turn, individual lessons must focus on assignments designed to ensure that students are introduced to, and given opportunities to practise, the core ideas and their components. Across the five years of the MYP, opportunities must be provided for students to revisit, refine and expand their understanding of core ideas within the discipline.

Conclusions and suggestions

The MYP and DP offer useful frameworks for designing units, assignments and assessments that focus on core science practices and core ideas within the discipline. Core practices include constructing scientific explanations using evidence and scientific principles, making predictions based on previous ideas or principles, or constructing and revising models based on new evidence. The core ideas or significant concepts include ideas such as evolution, the atomic theory of matter, ecosystems or gravity. Curriculums and instruction that integrate scientific practice and core ideas in science are more likely to take advantage of available instructional time by teaching modes of thinking and ideas that students will be able to employ to account for a broad range of natural phenomena.

The MYP and DP subject guides offer a variety of recommendations for teachers to design engaging and intellectually rigorous instruction in science. In this chapter, we have argued that, to be effective, teachers or curriculum designers employing these guides must be mindful of the big ideas in science that we want students to learn and attend to learning progressions.

Focusing on core ideas and big ideas in science

It may not always be clear in our local standards or curriculum frameworks what important science ideas should become the focus, but there are tools (see "Appendix 3") that can be used as resources to guide these instructional decisions. Deciding on which big ideas to focus does not have to be an individual struggle; there is a community of teachers engaged in the MYP and DP around the globe. Teachers can use the forums on the online curriculum centre (OCC), the associations of IB World Schools and their local school networks as resources in developing units based on core science ideas.

Sequencing lessons based on how learning progresses with experience over time

Once the core ideas, big ideas, or significant concepts have been identified, teachers must pay careful attention to how they sequence lessons so that students have an opportunity to build on prior understandings and make important connections. Students should be able to draw on big ideas to help connect related ideas in different lessons. Teachers must also be mindful of the big ideas when assessing students' progress and should measure students' progress in using the big ideas.

The MYP and DP have important and useful goals that can facilitate learning, such as making the content relevant to students' lives, engaging students in social issues related to their academic content, and keeping a strong emphasis on assessing what students can do with their understanding and using that to guide instruction. It is equally important not to lose track of core disciplinary ideas and practices. Students need to develop their understanding of the big ideas to make sense of the facts, terminology and new ideas they are being exposed to, otherwise the facts and terminology may not be efficiently retrieved and applied when needed. Core and big ideas are, therefore, a cognitive tool to facilitate future learning. They can also serve as a vehicle to develop a more coherent and aligned curriculum, instruction and assessments across grades so that students have multiple opportunities to build deeper understandings of the big ideas, which often takes time.

References

American Association for the Advancement of Science (AAAS). 1989. *Science for All Americans*. New York, USA. Oxford University Press.

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for Science Literacy: Project 2061*. New York, USA. Oxford University Press.

American Association for the Advancement of Science (AAAS). 2001. *Atlas of Science Literacy Volume 1*. New York, USA. Oxford University Press

American Association for the Advancement of Science (AAAS). 2007. *Atlas of Science Literacy*. Washington, DC, USA. Oxford University Press.

Cartier, JL and Pellathy, SL. 2009. "Integration with big ideas in mind: Using big ideas to guide choices about integrating science across the curriculum". *Science* and *Children*. Vol 46, number 8. Pp 44–47.

Chi, MTH, Feltovich, PJ and Glaser, R. 1981. "Categorization and representation of physics problems by experts and novices". *Cognitive Science*. Vol 5. Pp 121–152.

Corcoran, T, Mosher, F and Rogat, A. 2009. *Learning Progressions in Science: An Evidence-Based Approach to Reform*. Number RR-63. Philadelphia, Pennsylvania, USA. Consortium for Policy Research in Education, University of Pennsylvania.

International Baccalaureate. 2010. *Programme standards and practices*. Cardiff, UK. International Baccalaureate.

International Baccalaureate. 2010. *Sciences guide*. Cardiff, UK. International Baccalaureate.

International Baccalaureate. 2011. *Science across the continuum*. Cardiff, UK. International Baccalaureate.

National Research Council (NRC). 1996. *National Science Education Standards*. Washington, DC, USA. National Academy Press.

National Research Council (NRC). 2000. *How People Learn: Brain, Mind, Experience and School*. Washington, DC, USA. National Academy Press, Committee on Developments in the Science of Learning.

National Research Council (NRC). 2007. *Taking Science to School: Learning and Teaching Science in Grades K–8*. Washington, DC, USA. National Academy Press.

National Research Council (NRC). 2012. *A Framework for K-12 Science Education: Practice, Cross-cutting Ideas, and Core Ideas*. Washington, DC. National Academy Press.

Smith, CL, Wiser, M, Anderson, CW and Krajcik, J. 2006. "Implications of research on children's learning for standards and assessment: A proposed learning progression for matter and atomic-molecular theory". *Measurement: Interdisciplinary Research and Perspectives*. Vol 14, numbers 1 and 2. Pp 1–98.

Appendix 1

A unit example: "Chemistry That Applies"

Atomic theory is typical content in the MYP science curriculum. "Chemistry That Applies" is a unit designed by science education researchers to address a set of big ideas that are central to the core idea of the atomic molecular theory, as it applies to chemical reactions. The unit provides students with learning experiences that will nurture their understandings of such ideas. In what follows, we describe this unit in some detail, pointing out the characteristics that make it a model example. We examine the unit's focus on big ideas in science; the sequencing of learning along learning progressions and targeted learning challenges; and the design of lessons and assignments that elicit, advance and assess understanding. We conclude with a review of the qualities that make this unit exemplary.

Focus on big ideas

The unit seeks to help students understand the following four big ideas.

1. All substances are comprised of a finite set of atoms that determine the properties of the substances.
2. During a chemical reaction, the atoms of one or more substances rearrange to form different molecules that constitute a different substance (or substances).
3. During a chemical reaction, no atoms are destroyed or gained (the law of conservation of matter).
4. During chemical reactions, some amount of energy may be required to promote the reaction and, in some cases, may also release more energy than that which went into the reaction.

A traditional chemistry unit might focus on very specific chemical reactions or simply balancing chemical equations. In contrast, this unit focuses on foundational ideas of atomic theory. In other words, while more traditional curriculum units tend to focus on facts and terminology and lose track of the big picture, instruction that targets big ideas directly and explicitly focuses on the foundational principles or mechanisms that can be applied to explain a broad range of cases of chemical reactions.

Understanding big foundational ideas enables productive transfer of what we learn in science. Without an understanding of the model of chemical reactions embodied by the big ideas above, students are likely to fail to interpret and use other chemistry-related ideas with proficiency. While some big ideas may be addressed in traditional lessons, the whole set of big ideas are usually less explicit and not listed as key components of the model of how matter behaves during a chemical reaction. They are therefore not necessarily the targets of instruction or assessment for an entire unit or lesson set.

Sequencing instruction to support learning progressively over time attending to targeted challenges

To promote understanding of the key ideas above, this unit includes a series of lessons sequenced to develop an increasingly sophisticated model for what happens during a chemical reaction. By attending to how students' learning progresses teachers build on what students already know, focus on prior ideas students have and help students to develop progressively more sophisticated ideas through a series of carefully sequenced learning experiences. Thus, the unit takes advantage of a spiralling design where some concepts and phenomena are returned to in subsequent lessons so that students can apply and extend their new understandings. The unit focuses on four central chemical reactions: decomposition of water, burning, rusting, and a baking soda and vinegar reaction. The unit is also divided into several lesson clusters.

Cluster 1: Building on what students know—exploring macroscopic properties of substance

The first cluster begins with what students at this age should already know. In particular, students should know that different substances have different macroscopic properties, such as colour, texture, hardness,

and so on. Students are asked to collect evidence for the existence of chemical reactions by identifying the different macroscopic properties of the reactants and products.

Cluster 2: Experiments that challenge naive conceptions of mass

In the second cluster, students go through a series of lessons to address the common naive conception that mass may change during a chemical or physical transformation, such as when water boils, when a solid forms when two liquids react, or when a gas forms when a liquid reacts. Students make predictions and collect evidence for whether mass changes during the transformations (for example, they collect evidence that mass does not change during the baking soda and vinegar reaction).

Cluster 3: Engaging key ideas in atomic molecular theory to explain observations

In a central third cluster of lessons, students engage with the key ideas of the atomic molecular theory by using physical models to represent the molecules that make up the substances explored in each chemical reaction. Using these models, students describe the rearrangement of atoms during the chemical reactions and account for the conservation of matter during these events.

Cluster 4: Recasting naive conceptions of mass by further examining energy

Finally, in the fourth cluster, students explore the role of energy in chemical reactions and work through a set of lessons that help them to understand that, in some cases, chemical reactions need an "energy booster" to get the reaction going. Central here is addressing the naive conception that matter can be transformed directly into energy (or vice versa) or that energy can be created or destroyed. Students return to some of their previously explored chemical reactions, such as burning, decomposition of water, or rusting, to explore how "energy boosters" might be involved.

Designing lessons and assignments to elicit, advance and assess understanding of big ideas

To further illustrate quality instructional designs that support learning of big ideas, we turn to one of the key lessons in this chemistry unit (lesson 13 from cluster 3). In this mid-unit lesson, students are expected to model the reaction for the decomposition of liquid water (as a result of electrolysis) into gaseous hydrogen and gaseous oxygen.

Background: At this point, students have already explored the transformation first hand and have gathered evidence that a chemical reaction occurs here and substances different from water are formed. Specifically, students determined that oxygen was found in the bubbles coming from one terminal of the electrolysis apparatus because it caused a glowing splint to flame up; hydrogen gas was found at the other terminal because it caused a glowing splint to pop or spark. Students have also explored the idea that substances are comprised of atoms or molecules.

Assignment 1: Describing conservation of matter at the macroscopic level

Students are asked to recall from the previous lesson cluster that matter is conserved during a physical or chemical transformation (for example, they collected evidence that weight does not change during these transformations and defined this observation as the law of conservation of matter). Students are asked: How can atoms and molecules be used to explain the formation of new substances? How can they be used to explain the law of conservation of matter? These key questions are directly related to the big idea of the unit that atoms of substances rearrange during a chemical reaction.

Assignment 2: Creating plausible molecular models

Students are then asked to think about the substances in the bubbles resulting from the electrolysis of water and to represent the substances using space-filling models of molecules. In this case, simple marshmallows or gumdrops represent the different types of atoms that make up the molecules. Since bonds are not an essential part of the model at this point, it is unimportant to include sticks or links between the atoms in the representations. These models are thus well aligned with the big ideas that require students to keep track

of the type, number and arrangement of atoms existing in substances before and after the reaction. No extraneous or potentially distracting aspect of the models are included beyond these core elements of the big idea under study at this point.

Assignment 3: Exploring, testing and applying explanatory models

With help from the teacher, students are asked to think through a series of questions and represent what is happening to the substances using the models above. For example: If only water was present in the liquid (and the water level decreased during the reaction) and the gases are shown to be hydrogen and oxygen, then what types of atoms are needed to model the substances? Through modelling activities of this kind, students come to realize that not only do they need to keep track of the number and type of atoms present in their reaction but also how the atoms are attached to each other (that is, that there are two hydrogen atoms attached to each oxygen atom in water, two hydrogen atoms attached to each other in hydrogen gas, and two oxygen atoms attached to each other in oxygen gas).

Assignment 4: Explaining conservation of matter at the atomic level

Students are consequently asked to relate multiple representations: their physical models of the molecules, written words representing the substances, chemical formulas representing each substance, and finally the chemical equation. The chemical equation comes last (after students have struggled with what the substances are, what must be present and how they must be rearranged). At the end of this exercise, students are asked an important question relating to the big idea here: What do you notice in the number of atoms in the starting substance and the ending substances? The question gets at conservation of matter at the atomic level (previously students understood this at the macroscopic level where weight is conserved). Thus, through this series of activities, students should demonstrate that their understanding of the conservation of matter has shifted to a more sophisticated level.

Assignment 5: Reflecting on explanatory models' applications and limits

Towards the end of the lesson, students are asked to work in groups to discuss a series of "think-and-write" questions that address potential naive conceptions and allow them to apply their emerging understanding to new contexts. Specifically, they are asked: What is the difference between boiling water (another process where bubbles are observed and the water level decreases) and decomposition of water. The lesson's closing question addresses the common error of confusing chemical and physical changes. Students should realize boiling does not result in the formation of new substances and is therefore not a chemical reaction. Another closing question for this lesson focuses on application: Could chlorine gas or carbon dioxide result from the decomposition of water? If they understand the unit's big ideas, students should realize that this is not possible because chlorine and carbon atoms were not present in the starting substance. Students discuss these questions among themselves and use their models to support their arguments.

Assignment 6: Final explanatory synthesis

A final question asks students to describe to a friend, in their own words, what is going on in the decomposition of water. This, too, is a sense-making task that further requires students to synthesize the big ideas from the lesson. After this lesson, students engage in a similar set of activities for the other chemical reactions they explored earlier (for example, burning and rusting), but teachers gradually reduce scaffolding and support.

Conclusion

It should be evident from this description of the unit and the lessons and assignments above that big ideas are clearly the focus of the unit and all activities, tasks and assessments are concerned with such big ideas. It is not assumed that students will learn the big ideas from one lesson (even if it is the best-crafted lesson) but that they will do so by exploring big ideas in a variety of contexts (various chemical reactions) and representations (verbal, graphic, 3D).

Appendix 2

Learning progression for the atomic molecular theory organized around big ideas in physical sciences

The following table shows an example of learning progression by Smith, Wiser, Anderson and Krajcik (2006). It is an excerpt from the original table selecting grades 3–8.

Essential question	Big idea	Components of big idea	3–5-grade understanding	6–8-grade understanding
What are things made of and how can we explain their properties?	Objects are made of matter, which exists as many different material kinds. Objects have properties that can be measured and depend on the amount of matter and the material kinds they are made of.	Matter exists in different material kinds.	Objects are made of matter that takes up space and weight. Solids liquids are forms of matter and share these general properties. There are many different kinds of materials.	Matter has mass, volume and weight (in a gravitational field) and exists in three general phases (solids, liquids and gas). Materials can be elements, compounds or mixtures. All matter is made of a limited number of different kinds of atoms, which are commonly bonded together in molecules and networks. Each atom takes up space, has mass and is in constant motion.
		Objects have properties that can be measured and explained. Three important properties are mass, weight and volume.	Weight is a property of objects that results from the sum of its parts and can be measured. Volume is a property of objects that results from the sum of its parts and can be measured. The weight of an object is a function of its volume and the material it is made of.	Mass is a measure of amount of matter and is constant across location; weight is a force proportional to mass and varies with gravitational field. Solids, liquids and gases have different properties. The mass and weight of an object is explained by the masses and weights of its atoms. The different motions and interactions of atoms in solids, liquids and gases help explain their different properties.
		Material kinds have properties that can be measured and explained.	Materials have characteristic properties that are independent of the size of the sample (for example, density, flammability, conductivity).	Materials have characteristic properties independent of size of the sample (boiling and freezing points). Properties of materials are determined by nature, arrangement and motion of the molecules that they are made of.

Appendix 3

Additional resources

Core or big ideas

The *National Science Education Standards* (NRC 1996) and the *Benchmarks for Science Literacy: Project 2061* (AAAS 1993) have identified significant concepts and serve as a good reference. AAAS has in recent years constructed the Atlas of Science Literacy (AAAS 2001) which outlines all the benchmarks of science literacy and most of their connections from grades K–12 (AAAS 2001, 2007). The significant concepts in these atlas maps are those that are a prerequisite to many others in science ideas, or are concepts that many ideas build towards; in other words, they are the ideas with the most connections to other ideas.

The following is a link to these standards online.

- http://www.nap.edu/openbook.php?record_id=4962&page=R1

The *Atlas of Science Literacy Volume 1* can also be viewed at http://www.project2061.org/publications/atlas/default.htm.

Examples of units focused on big ideas

The curriculum unit "Matter and Molecules" can be viewed online at http://ed-web3.educ.msu.edu/reports/matter-molecules/.

The curriculum unit "Chemistry That Applies" is available at http://www.gwu.edu/~scale-up/documents/CTA.pdf.

Teaching for disciplinary understanding in mathematics

By Jon R Star with Veronica Boix Mansilla

Algebra: A key understanding in mathematics

Competence in mathematics, particularly in algebra, is widely recognized as a critical milestone in students' middle and high school years. In many public schools in the United States, algebra serves as a key "gatekeeper" course in that success in algebra is linked to participation in advanced coursework such as the IB Diploma Programme (DP), increased college attendance and graduation rates, as well as students' pursuit of mathematics- and science-related careers. The transition from arithmetic, typically taught in the early years, to algebra is a notoriously difficult one. This chapter explores the subject of algebra in some depth. We begin by examining the nature of algebra and why it is so important (and difficult) for students to learn. We then consider what it might mean for students to develop understanding in algebra. Finally, we identify critical challenges and approaches in the teaching of algebra.

Divergent views on the nature of algebra

In the IB Middle Years Programme (MYP), mathematics instruction is asked to serve a broad range of goals, including encouraging students to recognize and appreciate mathematics in the world around them; using language, symbols and notations appropriately; developing the patience and persistence sometimes necessary to solve problems; developing mathematical curiosity and reasoning, abstract, logical and critical thinking, as well as the knowledge skills, attitudes and confidence necessary to pursue further studies in mathematics. Algebra is one of five branches of mathematics MYP students study in pursuit of these aims. (The others are number, geometry and trigonometry, statistics and probability, and discrete mathematics.) Interestingly, the multiplicity of aims listed reflects a broader reality regarding algebra education: to date, there is no widespread agreement in the practitioner or research communities concerning what algebra is.

For some teachers and researchers, algebra is fundamentally about manipulating symbolic expressions and equations and gaining fluency with symbolic procedures. Others consider the central concern of algebra to be the exploration of, and representations of, functions or, more generally, about relationships between quantities that vary. Recently, a third view of algebra has prioritized algebraic reasoning as being more central than learning formal symbolic procedures for manipulating expressions. Certainly all of these views have merit. At present, one can find strong opinions among teachers and parents about which of these approaches is best for students. Unfortunately there is little research to help guide the difficult choices that teachers must make about how and what to teach under the name of "algebra".

On the one hand, it may seem as if this question—concerning the nature of algebra—is rather esoteric and something that researchers and mathematicians might debate but that has little relevance for teachers. However, this lack of agreement among teachers and researchers about the nature of algebra has fundamentally important consequences for instruction, as we examine below.

First, what should students know and be able to do prior to beginning an algebra course so they can be more successful in algebra? Surprisingly, educators and researchers often do not agree on what concepts and skills are critical prerequisites to later success in algebra, and the research base for various views on this issue is limited. For example, in the United States, the National Mathematics Advisory Panel recently focused its attention on three areas that it viewed as prerequisites for algebra: fluency with arithmetic operations,

rational number knowledge (including fractions) and measurement. There is certainly strong intuitive and theoretical support for the importance of these three areas, but there is no research directly linking each to student outcomes. For example, is it the case that students who have fluency with operations on fractions (such as adding fractions with unlike denominators) do better in a subsequent introductory algebra course than those who lack such fluency? Research for even basic assumptions such as this one is almost entirely absent, so teachers must draw on experience, careful observation and available tests to discern students' levels of readiness.

An alternative view about prerequisite knowledge that is held by some researchers and educators suggests that later success in algebra can be enhanced by the exploration of symbolic algebra in elementary school. Very interesting and innovative research is being conducted in many elementary schools, indicating that young students are surprisingly capable of understanding and demonstrating algebra concepts and skills that were previously viewed as beyond their capacities. Yet again, little or no research shows that students who engage with, and understand, symbolic algebra in elementary school subsequently do better in algebra when they encounter algebra as high school students.

Second, and related to the first point above, when students are learning algebra, how much should instruction emphasize working with symbols? There are divergent views on when students should receive instruction on symbolic algebra. It was not that long ago that all students in the United States were introduced to formal school algebra in the 9th grade, with an Algebra I course. In this organization of the curriculum, middle school was viewed as an opportunity to lay conceptual foundations for later symbolic and abstract study of school algebra. In the 1990s, many educators proposed an alternative—that the high school curriculum should be more integrated. As a result, topics from the traditional Algebra I course became more dispersed throughout the high school curriculum. Recently, algebra instruction appears to be shifting to middle school, with some topics traditionally associated with the Algebra I course, such as linear equation-solving, receiving instructional emphasis as early as the 7th grade in regular track courses.

Finally, why do we teach algebra at all? Educators are challenged by the public misperception of what algebra is and what it is used for. To many, algebra is centrally concerned with mysterious games played with the last three letters of the alphabet. Most adults (even those who had positive experiences with algebra) do not perceive that they use algebra in their daily personal or professional lives. For parents who hold these views on algebra, it is understandable that questions might arise about a school's push towards algebra for all students. This final point is especially important and deserves a more careful exploration. Why do we teach algebra?

Why should students understand algebra?

Three types of rationales are often given for the teaching of algebra: utility, gatekeeper, and mathematical.

First, an argument can be made that we teach algebra because it is useful in our daily lives. Some educators have argued, for example, that the skills and concepts that are integral to algebra—including solving and graphing linear and quadratic equations and inequalities—are directly applicable to many people's lives. While clearly everyday life problems, such as the relationship between investments and interests or telephone expenditure and use, can be represented in algebraic terms, it is rare that adults employ algebra to make sense of this information. We have found that while adults in some professions use algebra concepts and skills, many (even those in very mathematical or scientific fields) do not. A related argument about the utility of algebra highlights that the modes of reasoning and problem-solving capacities that are integral to algebra (and to mathematics more generally) are very useful in later life, both in the workplace and also in being an informed citizen in a world where numeracy (sometimes called mathematical literacy) has become essential.

A second reason for teaching algebra has to do with its role as a so-called **gatekeeper course**. A number of studies have shown that students who complete an algebra course are much more likely to graduate from college, take advanced mathematics courses, and pursue careers in mathematics, science and technology. Completion of an algebra course has become a de facto requirement for many educational and workplace opportunities. As such, some have gone so far as to refer to algebra as the new "civil right". The importance of algebra as a gatekeeper course may seem to be somewhat obvious; if students do not take a first year course in algebra, then it only makes sense that they will not be able to take (for example) calculus, which may limit their ability to attend college and pursue certain majors. As a result, many districts in the United States now require completion of an Algebra I course prior to completion of the 9th or even 8th grade.

A third reason for teaching algebra may be the most important, but it is also the most subtle and difficult one to make for students and parents. We believe that it is important that students learn algebra, because algebra plays a central role in the discipline of mathematics. Algebra represents students' first sustained exposure to the abstraction and symbolism that makes mathematics powerful. In essence, algebra is students' first (and perhaps only) glimpse of what mathematics is all about. Mathematics as a subject is unlike any other—it has a unique way of generating new knowledge (through proof) and its own discipline-specific norms for truth, elegance and beauty. In algebra, students can be exposed to fundamental aspects of mathematics, and this is an important reason that it is included in our curriculum.

What is algebra? Big ideas and essential competencies

Given the above discussion about differing perspectives on what algebra is and the rationale for teaching algebra, it seems important to articulate our view of what algebra is: **the use of representations to explore relationships between varying quantities**. Such a synthetic definition of algebra captures the core purpose of the discipline and contrasts with views of the subject typically available in school or national curriculums. Not uncommonly, mathematics teachers and students conceive algebra as a series of facts and procedures listed in their school or national curriculum that students need to master to complete their grade level preparation. Presented and covered in the forms of content lists, rarely are concepts organized in ways that capture the few most essential aspects of algebra—big ideas and understandings that underlie and organize quality algebra reasoning.

When viewing algebra as the use of representation to explore relationships between varying quantities, we may first consider algebra to be about using tables, graphs and symbols to explore these relationships. Consider the following examples. There is a relationship between your cellphone bill and how many minutes you talk on the phone. Similarly, there is a relationship between the balance of your savings account and how much money you add or subtract each week, the interest rate, and the balance. There is a relationship between the profit we make at a bake sale and the amount of cookies we sell, and the price of the ingredients. In these and other similar situations, it becomes possible to ask questions about the relationships between various quantities that we can subsequently explore with tables, graphs and symbols. Collectively, we refer to tables, graphs and symbols as "representations". Representations allow us to explore, generalize, predict and analyse features of situations where quantities vary. For example, when considering the bake sale example, representations such as graphs, tables and symbols allow us to figure out how many cookies we need to sell in order to achieve a desired profit.

If, as in the example above, algebra is seen as the use of representations to explore relationships between varying quantities, what matters most for students to learn if they are to become proficient in the domain? What are the big foundational ideas that students should master and what kinds of competencies will they need to develop to succeed in this area of mathematics? In what follows, we address these questions by introducing five foundational ideas and two core competencies that are central to algebra as a domain and

enable teachers to organize their instruction along essential conceptual threads that can be revisited over time to reach depth and breadth of understanding.

Five big ideas in algebra

In a recent publication (Lloyd, Herbel-Eisenmann, Star 2011), the United States' National Council of Teachers of Mathematics (NCTM) articulated a series of big ideas and related understandings that serve as foundations for a quality algebra education. The report posits that five big foundational ideas stand at the heart of algebra: expressions, variables, equality, representing and analysing functions, and solving equations. Each big idea is, in turn, accompanied by a series of specific understandings. In what follows we characterize each idea in some detail, describing some of the learning challenges they may present.

Expressions

Students understand **algebraic expressions** when they view them as building blocks and tools for exploring reasoning about, and representing, situations; when they understand that two or more expressions may be equivalent, even when their symbolic forms differ; or that a relatively small number of symbolic transformations can be applied to expressions to yield equivalent expressions.

Variables

Variables are tools that enable us to express mathematical ideas clearly and concisely. Variables have many different meanings, depending on context and purpose. Students demonstrate an understanding of variables when they can see that using variables enables us to write expressions whose values are not known or vary under different circumstances. Because using variables permits representing varying quantities, variables are particularly important in studying relationships between varying quantities.

Equality

The equals sign indicates that two expressions are equivalent. The equals sign can also be used to define or name a single expression or function rule. Students understand equality when they can use it to find the value(s) of a variable for which two expressions represent the same quantity. Finding the value(s) of a variable for which two expressions represent the same quantity is known as "solving an equation". Students understand relationships between expressions when they can also make sense of inequality. Inequalities indicate that one expression in the equation is greater than (or greater than or equal to) the other expression. In solving an inequality, multiplying or dividing both expressions by a negative number reverses the sign ($<$, $>$, $\leq$, $\geq$) that indicates the relationship between the two expressions.

Representing and analysing functions

What should students understand about functions? Functions provide tools for describing and understanding relationships between variables. One can represent functions in multiple ways—in algebraic symbols, situations, graphs, verbal descriptions, tables, and so on. Functions enable us to describe how variables change together. When we use a function in this way we are **modelling**, and the function we employ is called a "model". One important way of describing functions is by examining the rate at which the variables change together. It is useful to group functions into **families** with similar patterns of change because these functions, and the situations that they model, capture certain shared general characteristics. Students must understand that some representations of a function may be more useful than others, depending on how such representations are used. Linear functions have constant rates of change. Quadratic functions have rates of change that change at a constant rate. In exponential growth, the rate of change increases over the domain, but in exponential decay, the rate of change decreases over the domain.

Solving equations

Understanding how to solve algebraic equations requires that students understand yet another collection of interrelated ideas. First, they must see that general algorithms exist for solving many kinds of equations and that these algorithms are broadly applicable for solving a wide range of similar equations. However,

they must also see that, for some problems or situations, alternatives to these general algorithms may be more elegant, efficient or informative. For example, a general algorithm exists for solving linear equations. This algorithm is broadly applicable and reasonably efficient. Linear equations can be solved by symbolic, graphical and numerical methods. Depending on context and purpose, on some occasions one solution method may be more elegant, efficient or informative than another. Quadratic equations on their part can be solved by using graphs and tables and by applying an algorithm that involves **completing the square**. This algorithm, when expressed in a more compact form, is also known as the **quadratic formula**. Students understand the quadratic formula best when they can see its relationship to the broader aim of describing and exploring changing quantities and the collection of available tools algebra provides for doing so.

The above NCTM characterization of foundational ideas in algebra is revealing. It suggests that gaining proficiency in the discipline pivots on students' capacity to construct a robust understanding of a select number of interrelated constructs. Furthermore, it suggests that such constructs or big ideas must be seen in the light of their capacity to help us accomplish the goal of describing and comparing changing qualities. As the descriptions above reveal, the five big ideas proposed entail key nodes in a rich web of concepts, tools and approaches that can be examined over time and in various contexts, with growing levels of complexity. They offer the core for a spiralled curriculum.

While clear definitions of concepts add clarity about what exactly students should learn in algebra, one pitfall must be avoided. Proficiency in algebra does not mean students can merely define concepts such as expression, function, equality, and so forth; rather, it entails using such concepts flexibly. We turn to flexibility in the section below.

Two core competencies for representational flexibility

When we think about algebra as fundamentally involving the use of representations to explore relationships between varying quantities, understanding in algebra demands not only an understanding of foundational big ideas but also two complementary capacities. Students must become able to move flexibly **between representations**—that is, across multiple representations of given quantities. They must also gain flexibility **within representations**—that is, facility within each individual representation, such as tables, graphics and equations. We elaborate on these two capacities below.

Gaining flexibility *between* representations

This capacity means that students can analyse situations using graphs, tables and symbols, and subsequently make connections between these representations. Making these connections is a critical part of what we (and many others) think it means to understand algebra. Revisiting the cellphone bill example, a common billing arrangement is that one pays a flat rate for a set number of minutes, and then an extra fee for each minute that is used over this set limit. Thinking **between** representations means understanding what the extra charge per minute looks like on a graph—it is the slope. Similarly, the ability to move flexibly between representations involves understanding what the per-minute charge looks like on a table. It is not enough that a student could take a given situation and generate one representation; understanding in algebra means being able to use multiple representations and then make connections between them. The student who can talk intelligently about the extra charge (meaning the slope) and what this feature of the situation looks like on a graph and table understands much more about linear relationships than a student who is only able to produce one representation for this situation.

Gaining flexibility *within* representations

In addition to **between** representational flexibility, a related competency in algebra is **within** representational flexibility. Certainly, students need to know the concepts and skills that are related to working within a single representation, but they also need to know multiple strategies within that

representation, including the ability to select the most appropriate strategies for a given problem. As an example, consider strategies within a single representation (graphical) for graphing a line. There are many ways to graph a line. In particular, we can plot any two points; we can use the slope and the *y*-intercept; or we can use two special points (the *x*- and *y*-intercepts). The student who understands what he or she is doing in algebra with respect to graphing lines knows multiple ways to graph a line, and chooses to graph differently depending on the particulars of the lines to be graphed and/or the problem-solving situation. For example, such a student might choose to graph $3x + 2y = 12$ differently from $y = \frac{2}{3}x - 4$; in the former, the *x*- and *y*-intercepts are easily identified ((4,0) and (0,6)) and can be plotted; in the latter, the slope and *y*-intercept are easily identified ($\frac{2}{3}$ and (0,–4)) and can be used to graph this line. Similarly, and within the symbolic representation, there are many ways to solve equations, to simplify exponential expressions, to solve linear systems, and so on. Understanding algebra means knowing multiple ways to solve equations, and choosing a particular solution for a given problem because it is the best one.

Instructionally, we believe that it is not a good idea to teach students only one way to approach a type of mathematics problem. Teachers may think that they are doing students a favour by focusing on only one strategy, believing that they are making things easier. Such a teacher might preface his/her instruction on a single strategy by saying: "This method is all you need to remember; this method is the one way to solve this type of problem." But if students only know one way to solve a problem, and if they forget that way, or if they see a problem that they do not recognize, they are stuck with no way to move forward. However, if students have a more robust knowledge within a single representation and they can approach a given problem in multiple ways, they are better prepared to tackle both familiar and unfamiliar problems. Such an ability to move flexibly within representations is a key component of what it means to understand in algebra.

Teaching algebra for understanding—recommendations for instruction

In the preceding pages of this chapter, we have identified reasons for teaching algebra and discussed what algebra is—the use of representations to explore the relationship between varying quantities. We highlighted five big ideas and two competencies that are at the heart of algebra proficiency and may set the foundations for a quality spiralled curriculum. In this section we conclude with two broad recommendations that we feel are important to aim for when designing curriculum units in algebra. We offer practical guidance to teachers interested in the design of quality units of instruction in algebra and mathematics more generally. In these two recommendations, teachers must strive for balance between the sometimes opposing forces in algebra that have been discussed above. In the first, the balance in question is between the ideas of algebra and the procedures that are necessary for exploring these ideas. The second challenge balances the motivational power that comes with situating algebra in real-life contexts with a more disciplinary rationale for teaching mathematics.

Attending to mathematical processes

As suggested above, in algebra (and mathematics more generally) both ideas and procedures are important. For example, when teaching about linear equation-solving, we typically teach procedures for solving equations, and the rationale for these procedures draws upon the idea of equivalence and the mathematical axioms of equality. Similarly, when we teach graphing lines, there are important ideas related to graphing such as slope and rate of change, and there are also procedures for symbolically transforming equations into certain easy-to-graph forms. Mathematics curriculums over the ages have often been faulted for focusing too much on the procedures and not enough on the mathematical big ideas that underlie and rationalize the procedures. Overemphasis on procedures may result in students who believe that learning

mathematics is merely about memorizing a series of cookbook-like algorithms. Given that our mathematical goals for students involve integrated and robust knowledge of procedures and ideas, it is important yet challenging for teachers to consider ways to emphasize both.

Among the strategies suggested by research and best practices for meeting this challenge, one seems especially promising. When possible, teachers should prioritize tasks and instructional strategies that keep students' attention on the problem-solving **process**, rather than placing primary, or even sole, emphasis on the **product**. Attention to process involves considering big ideas and core competencies "in action", thus enabling students to refine and further ground their understanding. Too often students believe that their teachers are only interested in whether or not they arrived at the correct answer, with little attention to the strategy that they used. Encouraging students to explain the solution method, to justify their choice of strategy, to compare and contrast multiple strategies, and to generate alternative strategies are all promising practices that can communicate a teacher's interest in how a student went about solving a problem, rather than merely whether or not he or she solved the problem correctly. This particular strategy is incorporated in the use of MYP mathematics assessment criteria, which requires the student to demonstrate investigative skills, mathematical communication and reflection.

Linking real contexts with key mathematical understandings

The second recommendation that follows from our points earlier in this chapter relates to the rationales for teaching algebra and motivating students. As noted above, one reason that we teach algebra is that it is useful for students' lives. By situating mathematics in real-life contexts, we show students how and when algebra can be used, which research and best practice indicates can be motivating for students. Yet, at the same time, effective algebra instruction also draws upon the discipline-specific norms that are unique to mathematics. We teach mathematics so that students can begin to see and appreciate the importance of this discipline to the human endeavour, similar to why we teach art, music and great works of literature. In mathematics lessons, we want to engage students in the asking of certain forms of key mathematics questions: Why? When? How do you know? Under what conditions is it true? These questions have the potential to refocus a lesson that may appear to be solely about using mathematics in real life to one that uses a context as a vehicle for exploring important mathematics.

In practice, one useful way to implement this recommendation, and of balancing the motivational power of real-life contexts with an emphasis on deep knowledge of important mathematics, is through the use of a framing context for a unit. In the MYP, attention to providing a context for students occurs through using an area of interaction connected to significant concepts. A framing context is typically a real-life and rich problem that draws upon the mathematics ideas and procedures of the unit. A teacher might pose such a problem at the very outset of a unit. If the task is sufficiently well-designed, the students do not know how to approach the problem yet, but they are interested in the task and see how the lessons to come might be helpful in approaching the task. As the unit progresses, the framing context can be revisited, and students (as they learn the unit material) will be able to proceed further and further into the task and its solution. Revisiting the task serves as a reminder to students of what they are learning and why it might be useful; the task also serves to unify the many different topics that may fall under the umbrella of the unit. At the conclusion of the unit, the task can serve as an assessment of students' progress in the unit.

Conclusion

We began this chapter outlining various coexisting interpretations of what algebra is and why it is so important (and difficult) for students to learn. We claimed that algebra has been conceived as primarily concerned with the use of symbols or as fundamentally dealing with procedures and equations. We proposed a synthetic definition of algebra as *the use of representations to explore relationships between varying quantities*. We argued that quality teaching in algebra pivots on our capacity as educators to understand and focus students' attention on a few big ideas and principles that constitute the heart of

disciplinary understanding in the domain. We claimed that a curriculum centred on big ideas such as expressions, variables, equality, representing and analysing functions, and solving equations can set the foundations for a robust and meaningful instruction through which students are prepared to gain flexibility within and across representations over time. A big ideas curriculum of this kind moves beyond teaching facts or procedures in isolation—for example, solving quadratic equations—to place such procedures in a broader family of habits of mind that constitute the essence of mathematical knowledge and reasoning. In this sense, students revisit ideas such as equality or representing and analysing functions as they advance in their algebra course, understanding that different units in the course shed a novel light on the same collection of ideas. In the proposed big ideas and principles approach, "essential concepts" capture the core architecture of algebraic reasoning.

The problem with mathematics education, expert Alan Shoenfeld (2008) explains, is that when mathematics is presented as rules and procedures to be memorized and used, the discipline makes little sense to students. Commonly, mathematics is associated with certainty, with "knowing it", with being able to "get the right answer quickly". These cultural assumptions are reiterated daily in the experience that young people have in school where they are asked to follow rules set by their teachers and demonstrate that they can memorize and apply a rule when asked to (Swafford 2003; Darling-Hammond et al 2008). In sharp contrast, successful students in mathematics are invariably students for whom mathematics makes sense. Making sense of mathematics, and algebra in particular, requires that students have a chance to spend serious time experiencing the big ideas such as the ones introduced in this chapter, understanding variations in these ideas over time and developing representational flexibility. As Shoenfeld puts it, the equation is rather simple:

> If one teaches for skill, skill will come—but little else. If one teaches for skill, conceptual understandings and problem solving all three will come—and there will be little or no difference along the skills dimensions when you compare performance with instruction on skills alone.
>
> (Shoenfeld 2008)

References

Darling-Hammond, L, Barron, B, David Pearson, P, Schoenfeld, AH, Stage, EK, Zimmerman, TD, Cervetti, GN and Tilson, JL. 2008 *Powerful Learning: What We Know About Teaching for Understanding*. San Francisco, California, USA. Jossey-Bass.

Lloyd, G, Herbel-Eisenmann, B and Star, J. 2011. *Developing Essential Understanding of Expressions, Equations and Functions Grades 6–8*. Washington, DC, USA. National Council of Teachers of Mathematics.

Shoenfeld, A. 2008. "Mathematics for understanding". In L Darling-Hammond, B Barron, P David Pearson, AH Schoenfeld, EK Stage, TD Zimmerman, GN Cervetti and JL Tilson. *Powerful Learning: What We Know About Teaching for Understanding*. San Francisco, California, USA. Jossey-Bass.

Swafford, J. 2003. "Reaction to high school curriculum projects' research". In S Senk and D Thompson (eds). *Standards-based School Mathematics Curricula. What Are They? What Do Students Learn?* Mahwah, New Jersey, USA. Lawrence Erlbaum Associates.